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MAIZE SELECTION BY INBRED LINE APPEARANCE AND TEST-CROSS PERFORMANCE IN HIGH AND LOW PLANT DENSITIES

by

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INTRODUCTION

Following the demonstration of heterosis in crosses of inbred lines of corn, Zea mays L., Shull (1908) proposed that the object of the corn breeder should not be to find the best pure line, but to find and maintain the best hybrid combinations. Finding the best hybrid combinations continues to be the goal of contemporary corn breeders.

The most common method for the development of lines for hybrids involves self fertilization for several generations using visual selection for the more highly heritable characters and delaying evaluation of combining ability until homozygosity is approached. Visual selection for combining ability during the generations of inbreeding is rarely emphasized because of the commonly held opinion that it is ineffective. A disadvantage of this method is that the sampling of the population at each generation of inbreeding, if random for combining ability, tends to reduce the variability among lines. The result is a group of lines whose combining abilities are clustered about the mean of the original population.

The method of early testing proposed by Jenkins (1935) is a conceivable solution to this reduction of variability by random sampling. In the S_0 generation of a maize population, or the F_2 of a hybrid, the genetic variability among individuals is at a maximum. Superior germ plasm can supposedly be recognized and secured by test-cross performance rather than hazard its survival through a number of generations of random sampling. A problem with early testing is that the considerable expense of testing restricts the number of individuals which can be taken from the base population, minimizing the potential for improvement, since a small sample has a narrow genetic range.

To minimize the loss of genetic variability during the generations of inbreeding and selection, effective visual selection is a conceivable answer. This need not be as effective as testing in order to be as efficient, because efficiency is the product of two factors: effectiveness and cost. The lower cost of visual selection would allow a larger sample to be taken from the base population, with the consequent greater genetic variability.

A second problem of selection is the type of environment in which to practice selection. The ideal environment should enhance the heritability of the character being selected, and the performance of lines in the selection environment should be highly correlated with their performance across the range of environments in which they are to be used. While most breeders would probably agree with these generalities there is some disagreement about the specifics.

One school of thought proposes that selection for yield or combining ability should occur under conditions which maximize yield, i.e. a high productivity environment. An opposing school of thought suggests that, since the environment is usually sub-optimum for some factor, stress is therefore the normal situation. Crops must be developed to perform under the normal conditions which they must face, i.e. stress. Because the normal variations of environment may be dampened in a selection nursery or yield plots due to better than normal cultural practices and fertility conditions, or a sequence of favorable years, the selected lines may be unsuited to the normal range of environmental conditions which will occur. The application of some form of stress in the selection nursery or yield trials might alleviate this problem.

It was the purpose of this thesis to compare the effectiveness of visual selection with selection by test-cross performance, and to compare selection in two regimes: low and high population densities, hypothesizing that inbred lines selected on the basis of their performance in dense populations will also be superior in low population densities, but that lines selected on the basis on performance in low population densities may not necessarily be superior in dense populations.

DERIVATION OF EXPERIMENTAL MATERIALS

In 1954 a single-cross, M14 x C103, was self pollinated to provide F_2 plants for selection by four different methods: test-cross performance in low and dense stands and visual selection in low and dense stands. Previous studies in the Iowa State University corn breeding program (unpublished data) indicated that M14 in single-crosses was not adversely affected by dense stands, while C103 has, on occasion, had a high incidence of barren stalks in dense stands.

In a space planted nursery (density of 12,000 plants per acre), 138 F_2 plants were selfed and test-crossed to WF9 x I205, a tester which in previous tests appeared intermediate in its response across population densities. At harvest, 43 of the F_2 plants and their test-cross seed were discarded. The test-cross seed of the remaining 95 F_2 selections was retained for yield trials. The yield trials for this and the F_3 and F_4 generations were at two locations, for two years, in three replications in plots 1/392 of an acre in area. Plots were seeded heavily and thinned to the required population density, for an increase in the precision of the stand.

The test-cross seed of each F_2 selection were grown in the yield trials at two population densities or rates: rate 1, 16,000 plants per acre and rate 2, 24,000 plants per acre. The F_3 and F_4 were tested in the rates at which the previous generation of the selection had been tested and judged superior.

For example, if a particular F_2 in test-cross performance was superior at rate 2 but inferior at rate 1, the F_3 from that F_2 was tested only at rate 2. Some F_2 did well in both rates, and so their F_3 were tested at both rates. Test-crossing of the F_3 and F_4 was performed by selection of one to three plants from an F_2 or F_3 progeny row, respectively, and crossing to the tester. The inbred rows in the crossing nursery consisted of 16 plants at a population density of 12,000 plants per acre. Individual plants were selected by visual discrimination, selfed and crossed to the tester. These were reselected at harvest for resistance to the stalk rot pathogen, Diplodia zeae (Schw.) Lév, as determined by previous inoculation. The F_2 plants were not tested for stalk rot resistance.

No profound understanding and interpretation of the performance of the selected lines is possible without knowing the conditions in which the testing occurred and the general performance of the lines in the testing stages.

Test-crosses of F_2 plants were tested in 1956 at Clarion and Storm Lake, but only at Clarion in 1957. In 1956 the Storm Lake location was not harvested due to severe drouth and hail damage. At Clarion isolated pockets of drouth stress in 1956 were responsible for a high coefficient of variation, 14.8%. Precipitation in 1957 was adequate in quantity and distribution, but temperatures were below normal. The test was very uniform as indicated by the low coefficient of variation of 7.4%. In both years most lines exhibited poorer stalk quality than either M14 of C103. At rate 1, C103 x tester was higher yielding than M14 x tester, while at rate 2 the order was reversed. As a result of this, selection at rate 1 may have favored for C103 germ plasm while at rate 2 it may have favored for M14 germ plasm. Relative estimates of stalk strength were similar for both rates, although stalk breakage was higher at rate 2. There was an entry x rate interaction for yield, indicating that lines varied in their response to population rates. There appeared to be very little entry x year interaction.

On the basis of F_2 test-cross performance, 33 F_2 families from rate 1 and 30 F_2 families from rate 2 were selected for further study in the F_3 at rate 1 and 2, respectively. Seventeen F_2 families were common to both.

In 1958 the F_3 were grown ear-to-row from F_2 ears in the crossing nursery, and the test-crosses made as previously outlined. The test-crosses were entered in duplicate experiments near Ankeny and Hampton in 1959 and 1960.

In 1959, 76 selections were tested at rate 1, 67 at rate 2, with 40 common to both sets. There was very little root or stalk lodging. At Ankeny, late planting and soil variability resulted in a high coefficient of variation, 12.8%. On the basis of 1959 data the first set was reduced to 59 and the second set to 51 selections for the second year of F_3 testing.

Extreme winds at Hampton in early September of 1960 resulted in drastic root and stalk lodging. The only data taken were yield and grain moisture at harvest. At Ankeny there was considerable root lodging but little stalk breakage. In these two years of testing few of the selections had stalk strength equal to C103 x tester, but many were as good as M14 x tester. On the basis of 1959 and 1960 data 28 plants were selected for study at rate 1 and 26 at rate 2, in the F_4 with six lines common to both rates.

Test-crosses of the F_4 were compared in duplicate experiments near Hampton and Ankeny in 1962 and 1963. In 1962, 58 selections were tested at rate 1, and 51 at rate 2, with 12 common to both rates. At Hampton there was early root lodging at rate 1 and both root and stalk lodging at rate 2. None of the test-crosses had root and stalk strength equal to C103 x tester. In 1963, 31 test-crosses of F_4 were grown at rate 1 and 32 at rate 2, of which four were common to both rates. There was little root or stalk lodging at rate 1, but at rate 2 there was sufficient stalk breakage to be of selection value. Two of the four common lines were outstanding.

Twenty-nine lines survived the three generations and six years of selection and testing, sixteen lines within each rate, three of which were common to both groups. Within the groups of 16 lines, each line had a different F_2 ancestor. Because 46 F_2 selections were only reduced to 29 F_4, selection in the

F_3 and F_4 was mainly within families.

Table 1 summarizes the yield and lodging data for the six years of testing. These data illustrate that the environmental variation among locations, years and population rates favors selection of different genotypes in different environments. In 1956 C103 germ plasm was favored at both rates. In 1962 there was selection for M14 germ plasm at rate 1 but C103 at rate 2.

Seed from all selfed ears within each F_5 row was bulked as F_6 seed with little or no artificial selection. This seed was planted in a crossing nursery to make test-crosses for the comprehensive hybrid yield trials. In 1963 F_6 plants were selfed to provide seed for inbred trials in 1964.

The source material for the study of visual selection was the same 95 F_2 plants that were selected for evaluation in the test-crosses of 1956. Progeny of the F_2 selections, F_3, were planted ear-to-row in a breeding nursery at densities of 12 and 24 thousand plants per acre. A plot at the first rate contained 25 plants, and at the second rate, 50, where the stand was perfect. At rate 1 all plants with good phenotype were eligible for selection, but at rate 2, plants had to be bordered. Due to missing plants, about 23 plants at rate 1 and 30 at rate 2 were eligible for selection.

For three generations, at pollinating time and harvest, selection for general vigor, disease resistance and simultan-

Table 1. Summary of agronomic data for entries in test-cross trials at two population rates; rate 1 = 16,000 and rate 2 = 24,000 plants per acre

Generation	Year	Entry	Yield bu/acre Rate 1	Yield bu/acre Rate 2	Lodging Rate 1	Lodging Rate 2
F_2	1956	mean[a]	91.2	78.9	16.2	31.2
		M14	81.7	76.6	7.5	21.7
		C103	104.8	82.8	4.8	15.9
		M14 x C103	85.4	84.9	10.8	48.6
	1957	mean[a]	102.0	102.1	1.8	2.9
		M14	95.1	100.7	0.9	1.6
		C103	100.2	91.0	0.2	1.1
		M14 x C103	99.4	100.9	1.6	3.0
Generation mean		lines saved	96.6	90.5		
		checks	94.4	89.5		
F_3	1959	mean[a]	101.3	95.0	2.6	5.5
		M14	102.8	107.4	0.9	6.1
		C103	98.0	66.8	1.7	1.1
		M14 x C103	94.2	77.2	2.2	3.3
	1960	mean[a]	129.3	124.1	4.3	2.5
		M14	125.3	119.3	13.9	3.9
		C103	126.0	123.0	0.9	0.6
		M14 x C103	122.5	120.7	1.4	3.0
Generation mean		lines saved	115.3	109.5		
		checks	111.5	102.4		
F_4	1962	mean[a]	121.6	115.4	7.1	20.5
		M14	128.4	112.9	11.7	36.4
		C103	119.9	119.6	0.8	5.0
		M14 x C103	113.2	107.7	6.5	9.9
	1963	mean[a]	133.4	134.1	1.2	2.6
		M14	125.4	118.7	0.7	5.7
		C103	134.3	126.8	1.3	1.7
		M14 x C103	137.3	134.9	2.0	3.3
Generation mean		lines saved	133.0	129.8		
		checks	126.5	120.2		

[a]mean of all selections

eous release of pollen and silk emergence was practiced among and within rows. The latter character was considered because inbreds which have delayed silking under stress transmit this quality to their progeny, resulting in an incidence of barren-ess. In the F_3 many lines were eliminated at rate 2 because of barreness or delayed silking. If a plant was selected at rate 1, it was planted ear-to-row at rate 1 in the following year and generation. In the F_6, entire rows were selected and bulked as families. All F_7 were grown in 1963 at rate 1 for an increase of inbred seed, and some mild selection among progenies was practiced.

PART I. AGRONOMIC PERFORMANCE OF SELECTED LINES

REVIEW OF LITERATURE

The effectiveness of visual selection for combining ability during inbreeding of corn has been a subject of broad dispute for many years. Several authors, including Jenkins (1929), Sprague and Miller (1952), deny any influence of visual selection during inbreeding on the general combining ability of the selections. Others, Hayes and Johnson (1939) and Osler, Wellhausen and Palacios (1958), support the efficacy of visual selection on combining ability.

Two of the most comprehensive correlation studies of inbred characters which might conceivably be used for hybrid prediction were reported by Jenkins (1929) and by Hayes and Johnson (1939). Jenkins studied 18 inbred characters, but found only a few with any predictive value: plant height, number of nodes, number of nodes below the ear and grain yield. The multiple correlation of these characters with yield in single-crosses was R = +0.42. This was a minimal value because of the maximum non-additive gene effects in single-crosses. In parent - F_1 correlations there was no opportunity for the averaging out of non-additive gene effects, since all F_1 plants within a single-cross were almost identical. Because non-additive effects were a consideration in F_1 hybrid yield, but only the additive components existed in the inbreds, there was a tendency for the hybrids to be unlike their parents.

Hayes and Johnson (1939) used inbred - top-cross correlations to support their theory. The use of top-crosses tended to average out epistatic and dominant effects because each F_1 from such a cross was unique. The gametes from the inbred of a cross were similar, but the gametes from the tester were segregants. Favorable and unfavorable combinations due to non-additive effects tended to cancel out each other. These authors used 12 vigor characters of inbreds, most of which were used in the previous study by Jenkins, and found a multiple correlation value of $R = +0.666$.

Since visual selection during inbreeding is merely a special case of phenotypic selection, the relationship between S_1 yield performance and general combining ability is relevant to the visual selection controversy. Kwon and Torrie (1964) found significant ($p = .01$) correlations between visual scores and actual yields in two soybean populations. There was very close agreement among three observers, two of whom were inexperienced graduate students. Their expected gain using visual selection was 50% as efficient as using plot yields.

Genter (1963) suggested that if heterosis results primarily from "additive and dominant gene effects, progeny performance in early generation inbred lines should evaluate their general combining abilities better than test-crosses". He cited several authors who found correlations between S_1 performance and top-cross performance ranging from $r = +0.59$ to $+0.86$ for grain yield.

Genter and Alexander (1962) reported correlations between S_1 and test-cross performance which were as close as correlations between two sets of three-way test-crosses (the S_1 lines crossed to two single-cross testers). Yields of a synthetic of S_1 performance-derived lines were superior to yields of a synthetic of test-cross-derived lines, in two consecutive cycles. The advantage of S_1 over test-cross performance was due to the masking effect of the testers.

Lonnquist and Lindsey (1964) compared S_1 line performance versus top-cross performance. Their three highest yielding S_1 derived lines when tested in top-crosses yielded 59.5 bu. per acre, compared to the three top-cross selected lines which yielded 66.9 bu. per acre. Although there was a greater range of expression in the S_1 yields there was also a greater genotype x environment interaction. The latter indicated a greater sensitivity of S_1 lines to environmental differences. The authors did not comment on using this sensitivity as an aid in selecting for adaptability.

The breeders in favor of visual selection for combining ability emphasize the existence of correlations between one or more inbred characters and combining ability. Their adversaries, while agreeing with the existence of these correlations, emphasize their low values. Gilbert (1961), using a mathematical model, demonstrated that with intense selection, even small correlations can be valuable in securing considerable genetic advance.

The literature appears barren of information on the effectiveness of visual selection on the improvement of inbred lines *per se*. There is general agreement among most breeders that it is effective. For critical information one must turn to autogamous crops which are somewhat analogous to inbred lines of corn. The analogy falls short of perfection because these crops are considered to be governed by additive gene action, primarily, with respect to yield potential, whereas corn is thought to have considerable dominant gene action, some of which is present in segregating generations. This limitation must be kept in mind.

From the F_3 of a barley variety cross, Atkins (1964) selected 25 good plants, 25 random plants and 25 poor plants on the basis of phenotype. When placed in yield trials in the F_5, F_6 and F_7, they yielded in the expected descending order of good, random and poor. Because the difference between the good and poor lines, although significant ($p = .01$) was less than a bushel per acre, and between the good and random lines was only 39 pounds per acre, he concluded that visual selection on a single plant basis was not practical, except perhaps in the identification of low yielding lines.

Frey (1962) found visual selection ineffective when based upon single oat plants but effective when based upon progeny rows. Hanson, Leffel and Johnson (1962) working with soybeans found that observers were capable of discriminating extremes, visually; principally the poor yielding plots. They concluded that unless a breeder is dealing with a cross which gives as extreme range of progenies, visual discrimination should be used primarily to discard poor yielding genotypes rather than the selection of superior ones.

The general consensus of opinion among these and other authors is that the effectiveness of visual selection for yield depends upon wide variation in the source population, progeny row performance and the culling of poor genotypes rather than the selection of superior ones.

Jenkins (1935) investigated the effectiveness of selection by top-cross as well as possible influences of chance changes in combining ability during inbreeding. The progeny of random ears from two open-pollinated varieties were top-crossed; two sister lines from each family in each generation. One of these sister lines was the selected line and the other, the discarded line. Selfing was continued until the S_8.

Seven families from the variety Iodent and five families from Lancaster were represented in yield trials by the selected line of each generation. The trends from S_1 to S_2 were upward in Iodent and downward in Lancaster, but from S_2 to S_8 the average combining abilities of the seven Iodent families were constant, while Lancaster showed an erratic upward trend. Analysis of variance showed that the variation due to family was significantly larger than that due to interaction between family and generation. For this reason Jénkins concluded that families had acquired their individuality as parents of top-crosses very early in the inbreeding process.

Richey (1945) reanalyzed Jenkins' data on the theory that selection in some families might have been effective and ineffective in others. Averaging over families could have obscured these results. In order to smooth the data without masking trends, he averaged yields of individual families by two generation periods. This did reveal some lack of corresponsence between early and later generation performance. High performance at fixation originated with a trend which began at S_4 - S_5. Because of this he proposed that selection should be delayed until S_4, after which test-cross performance should be used for selection among families, and visual selection for discrimination within families. He later (1947) noted that inbred performance of the S_3 or S_4 lines was about as good a criterion of combining ability as top-cross performance and at a much lower cost. He (1945) noted that "with selection against recessives of major effect, and with progression towards fixation, progeny performance of selfs and crosses will tell more nearly the same story".

Lonnquist (1950) studied the stability of combining ability from S_1 to S_4 generations of lines from Krug yellow dent.

Divergent selection for high and low combining sublines within each selfed generation of the selected S_1 lines was practiced by top-crossing several plants within each S_1 line to the parental variety. On the basis of top-cross performance a high and low combining S_1 plant was chosen to initiate the two directions of selection for yield within each S_1 progeny. The selfed progeny were grown ear to row, and selection within the S_2, S_3 and S_4 continued in like manner. In 1948 the top-crosses of selected high and low lines were tested in a single experiment.

Selection for both low and high combining ability for the several generations within the S_1 families was successful. He concluded that although selection based upon top-cross performance could greatly modify the combining ability of S_1 lines in subsequent selfed generations, early testing of S_1 lines provided a better sample of material in which to inbreed than a random sample from the same population.

The problem of which type of environment in which to practice selection has been raised by a number of authors for two main reasons: genotype x environment interaction and differences of heritabilities in different environments. The former is important because it measures the failure of genotypes to have the same relative performance in different environments. This causes an obvious problem in selection and discarding. The second problem arises because the breeder normally desires to select in an environment which maximizes the heritability of the character which he wishes to improve.

Among the components of environment which have been studied are: years, locations, dates of planting, moisture supply, light intensity, toxic conditions, fertility levels and population densities.

Sprague and Federer (1951) evaluated 10 top-cross, 18 single-cross and 25 double-cross experiments. For the single- and double-cross experiments, hybrid x location and hybrid x year interactions were quite important.

In a study of rice genotype interactions with planting date and plant density, Kariya and Yamamoto (1963) found no interaction of varietal yields with planting date, but varietal yields did interact with planting density. Heritabilities for the following characters decreased with planting rate: culm and panicle length, number of panicles, panicle weight and heading date. They concluded that it is advantageous to select early generations in low densities.

Corn inbreds were studied by Huber (1956) in hybrid combination for efficiency of water utilization at different population densities. In low populations there were no apparent differences, but in high populations corn hybrids differed widely in their efficiency of water utilization.

Light effects on different corn genotypes were studied by Knipmeyer, Hageman and Earley (1962). They found that as population density was increased light became a limiting factor in yield potential. Genotypes varied in their response to different light intensities. Thut and Loomis (1944) demonstrated that plants growing in varying light intensities exhibited characteristic differences in growth and development.

Soybean variety yields were found to interact across a range of salt concentrations by Abel and MacKenzie (1964). Salt tolerant varieties improved in their rank of seed yield as salt concentrations were increased.

Selection in high fertility was found, by Frey (1964), to produce oat selections with superior yield stability. One group of oat selections had been selected for several generations on a gravelly eroded knoll. A second group was selected in the adjacent fertile area of deposition. Although there were no significant yield differences attributable to selection methods in subsequent yield trials, the mean squares for strains x environments suggested a superior yield stability for those lines selected under conditions of high fertility.

Gotoh and Osanai (1959 b) selecting under three fertility levels obtained superior wheat lines more frequently in the low fertility selection nursery, and these had a wider adaptability to fertilizer levels. Heritability for yield was found to be higher in the low fertility nursery.

Nine single-cross corn hybrids grown at various populations and nitrogen levels by Lang, Pendleton and Dungan (1956) were found to have hybrid x population and hybrid x nitrogen level interactions for yield. Similar studies in wheat by Pendleton and Dungan (1960) indicated differential responses to fertility and population but rankings remained the same. This was consistent with the findings of Lamb and Salter (1936) and Warzella (1943) who found that yield of wheat varieties did interact with fertility levels but rankings remained the same.

Minor inconsistencies in apparent ranking in a corn variety trial at different levels of productivity led Mooers (1933) to conclude in favor of variety testing under low and high productivity conditions. No presentation of tests of significance were offered to support the change in ranking as being other than possible chance deviations.

Gotoh and Osanai (1959 a) compared selection for yield under different densities of progenies of a wheat cross. They concluded that the higher efficiency which they had in the wide spacing was due to the increased phenotypic variation. This was in contrast to the findings of Guitard, Newman and Hoyt (1961) who found that selection from space planted early generation hybrid wheat, oats or barley was less efficient than selection in dense seedings.

Soybean plant competition at close plant spacings was found to inflate both individual plant variability for a constant genotype and the genetic component as well, giving an extremely biased description of individual plants (Hinson and Hanson 1962). The bias in yield comparisons of individual plants was due to the competitive advantage of a single plant genotype plus the competitive disadvantage of its neighbors. Evaluation of individual plants for secondary characters such as chemical differences was little influenced by competition.

Weber (1957) compared selection of individual soybean plants from bulk hybrid soybean populations in different plant spacings, attempting to improve yield but maintain constant maturity. The progenies of these selections, evaluated in replicated drilled plantings showed no yield, height or lodging differences among selections from different spacings.

Interactions of corn genotypes with population densities were studied by Rossman (1955) and Woolley, Baracco and Russell (1962). Rossman found that hybrids which were good at low populations were generally good at high populations, but that sufficient exceptions existed to warrant testing at two population densities. The latter authors studied four inbred lines in all possible combinations of single-crosses in population densities and spacing patterns. In one of the two experimental years there was a significant interaction of crosses with populations, and in the other, of crosses with spacings, each involving change in rankings of crosses.

Ferguson (1962) in an intensive study on the combining ability of inbred corn lines as influenced by population density, used three lines from a group whose maximum yield was attained at 20,000 plants per acre, the Low group, and three lines whose maximum yield was attained at 28,000 or more plants per acre, the High group. The general and specific combining abilities were appraised in a modified diallel cross in a number of different planting densities.

The High group was superior at both low and high population densities, while the Low group did well only at low densities and suffered a decline in yield as population was increased. The High group showed no yield depression up to 28,000 plants per acre after which yield declined slightly to 32,000 plants per acre, the highest population. The relative rank of individual lines was the same from year to year and across population densities, with a single exception whose change in rank was caused by a yield difference of half an H.S.D.

The mean yields of Low x Low crosses increased from 12,000 to 24,000 plants per acre and then dropped sharply. The High x High increased to 28,000 and then levelled off to 32,000. The Low x High showed an interesting heterotic effect, being superior to Low x Low and High x High at the four highest rates.

Analysis of variance for ear moisture showed an influence of planting density, but the small differences in response of different varieties was not considered to be of practical importance.

Stalk breakage was more influenced by years and locations than by populations. Hybrids varied in their susceptibility but there was no interaction with populations, and selection for performance in high populations had no measurable effect.

MATERIALS AND METHODS

The first comprehensive evaluation of all the selected lines was made in 1964 when the test-crosses of the lines were studied at several locations and lines per se were studied at one location. The inbred selections and M14, C103 and M14 x C103 had been crossed with WF9 x I205 and Ia. 4810. Single-cross WF9 x I205 was selected because it was the tester used in the derivation of the selections by the test-cross procedure. Ia. 4810 was an unrelated tester and, because it is a double-cross, was expected to give a satisfactory measure of general combining ability.

The inbred selections were evaluated as test-crosses in two sets of hybrid trials. In the one set seed from like selection methods and common tester were bulked and became single entries, i.e. seed from all of the lines which had been selected by test-cross performance at low stands and crossed to WF9 x I205, 16 crosses, were bulked to produce a single entry. There were eight such composited entries; two from each selection method, one with the single-cross tester and one with the double-cross tester. Each of the test-cross derived composites contained the three lines common to selection at low and high rates, since they would have been selected had only a single rate been used. The second set of hybrid trials consisted of the individual lines in crosses with WF9 x I205, each test cross retaining its identity. In both sets of experiments three checks, M14, C103 and M14 x C103 crossed with the same tester(s) as the other entries were also grown.

In order to simplify the presentation of data and discussion some abreviations will be used.

E - (elite lines) lines selected by test-cross performance at both rates,

LT and HT - lines selected by test-cross performance in low and high rates, respectively,

LP and HP - lines selected by visual discrimination in low and high rates, respectively,

T_1 - WF9 x I205 and T_2 - Ia. 4810 testers.

Composite Test Field Procedures

The 14 crosses in the composite trials, bulks of the four selection groups and the three checks crossed to the two testers, were placed in a split-plot arrangement of a randomized complete block design. Main plots consisted of five population rates and sub-plots of the 14 crosses. Fifty different randomizations of the sub-plots were used for two replications of five rates of planting at each of five locations. Rates were randomized within each replication.

A sub-plot consisted of a single row, 400 inches long and 40 inches wide. These were bordered only between replications to minimize the competition of adjacent sub-plots at different population rates. Alleyways of 40 inches, which were left between main plots to facilitate access, were credited to plot area. The details of planting were as follows:

Plants / acre	Hills per sub-plot	Final plants per sub-plot	Distance between hills inches
11,760	14	30	27.7
15,680	19	40	20.0
19,600	24	50	15.7
23,520	29	60	12.9
27,440	34	70	10.9

With perfect stand a sub-plot consisted of two end hills with three plants in each, 360 inches apart, and a number of interior hills each containing two plants. To facilitate planting at the proper inter-hill distances, five chains with markings to indicate hill spacings were used. The seed was hand planted with one extra kernel per hill and later thinned, to increase the precision of the population densities. These five densities or rates will be referred to as 12, 16, 20, 24 and 28 thousand plants per acre, or as rates 1 through 5, respectively.

The locations, planting dates, previous crops and fertilizer applications are listed in Table 2.

Table 2. Locations, planting dates, previous crops and fertilizer applications in 1964

Location	Ames			Ankeny			Hampton			Newell			Sheldon		
Planting date	May 22			May 27			May 19			May 9			May 15		
Previous crop	soybeans			corn			corn			corn			soybeans		
Fertilizer	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
at planting	80	18	16	111	22	41	126	56	64	6	11	20	80	18	16
side dressing	45	0	0	50	0	0	0	0		100	0	0	45	14	8
total	125	18	16	161	22	41	126	56	64	106	11	20	125	32	24

Seed bed preparation and cultural practices were in accordance with those normally accepted as desirable for farm corn production. Harvesting was done by hand and dropped ears were gleaned and credited as yield. From each plot 12 or more ears were sampled for grain moisture, which was determined in a Steinlite Electronic Moisture Tester. Plot yields were converted to cwt of shelled corn at 15.5% moisture prior to mean computation and analysis of variance. Additional agronomic data recorded were: root lodging, stalk lodging, number of dropped ears and per cent of barren stalks.

The weather in 1964 was conducive to the production of average yields of corn in Iowa. Detailed climatological data are presented in the appendix.

Composite Test Statistical Procedures

The form of the analysis of variance for an individual location was:

Source of variation	Degrees of freedom	Expectation of mean squares
Replications (R)	1	$\sigma_a^2 + pteK_r^2$
Rates (P)	4	$\sigma_a^2 + rteK_p^2$
Replications x rates error a	4	σ_a^2
Testers (T)	1	$\sigma_b^2 + rpeK_t^2$
Entries (E)	6	$\sigma_b^2 + rptK_e^2$

Source of variation	Degrees of freedom	Expectation of mean squares
Testers x entries	6	$\sigma_b^2 + rpK_{te}^2$
Testers x rates	4	$\sigma_b^2 + reK_{tp}^2$
Entries x rates	24	$\sigma_b^2 + rtK_{ep}^2$
Entries x testers x rates	24	$\sigma_b^2 + rK_{etp}^2$
Error b	65	σ_b^2

Bartlett's (1937) test of homogeneity of variance was applied to the error b mean squares of the five locations. This test indicated that these variances were different at the 5% level of probability but not at the 1%. This unfortunate circumstance was disregarded and a combined analysis of variance was computed for the five locations. Because of this the tests of significance will not be at the exact probabilities given, but the deviation is expected to be slight.

Replications, rates, testers and entries are considered to be fixed effects. In the combined analysis the locations are considered to be random. The form of the combined analysis with the expectation of mean wquares is presented on the following page.

Source of variation	Degrees of freedom	Expectation of mean squares
Locations (L)	4	$\sigma_a^2 + rpte\sigma_l^2$
Reps/L error a	5	σ_a^2
Rates (P)	4	$\sigma_b^2 + rte\sigma_{pl}^2 + rlteK_p^2$
P x L	16	$\sigma_b^2 + rte\sigma_{pl}^2$
Error b	20	σ_b^2
Testers (T)	1	$\sigma_c^2 + rpe\sigma_{lt}^2 + rlpeK_t^2$
T x L	4	$\sigma_c^2 + rpe\sigma_{tl}^2$
T x P	4	$\sigma_c^2 + re\sigma_{lpt}^2 + rleK_{tp}^2$
T x P x L	16	$\sigma_c^2 + re\sigma_{lpt}^2$
Entries (E)	6	$\sigma_c^2 + rpt\sigma_{le}^2 + rlptK_e^2$
E x L	24	$\sigma_c^2 + rpt\sigma_{le}^2$
E x P	24	$\sigma_c^2 + rt\sigma_{epl}^2 + rltK_{ep}^2$
E x P x L	96	$\sigma_c^2 + rt\sigma_{epl}^2$
E x T	6	$\sigma_c^2 + rp\sigma_{lte}^2 + rlpK_{te}^2$
E x T x L	24	$\sigma_c^2 + rp\sigma_{lte}^2$
E x T x P	24	$\sigma_c^2 + r\sigma_{lpte}^2 + rlK_{pte}^2$
E x T x P x L	96	$\sigma_c^2 + r\sigma_{lpte}^2$
Error c	325	σ_c^2

where r = number of replications, l = number of locations, p = number of rates, t = number of testers and e = number of entries

F tests of significance of mean squares in the combined analysis were made as follows:

(a) the entries x testers x rates x locations interaction was tested against error c

(b) the entries x testers x rates interaction was tested against the entries x testers x rates x locations interaction

(c) the entries x testers x locations interaction was tested against error c

(d) the entries x testers interaction and its orthogonal components were all tested against the whole entries x testers x locations interaction

(e) the entries x rates x locations and orthogonal components were tested against error c

(f) the entries x rates interaction and orthogonal components were tested against the entire entries x rates x locations interaction

(g) the entries x locations interaction and its orthogonal components were tested against error c

(h) entries and its orthogonal components were tested against the whole entries x locations interaction

(i) the testers x rates x locations interaction was tested against error c

(j) the testers x rates interaction was tested against the testers x rates x locations interaction

(k) the testers x locations interaction was tested against error c

(l) locations was tested against replications within locations.

In the analysis of variance, the degrees of freedom and sums of squares for entries and various entry interactions were divided into the orthogonal components which were most relevant to this study, i.e., LT vs HT, LP vs HP, T vs P, selections vs checks and others of lesser importance, viz., M14 vs C103 and M14 plus C103 vs M14 x C103. Similarly, the degrees of freedom and sums of squares for rates and various interactions involving rates were partitioned into rates linear, rates quadratic and remainder, by the method outlined by Le Clerg (1957). The use of most of the error terms were justified by the expected mean squares, but in the instances of the orthogonal comparisons and subdivisions of rates, the pooled interactions with locations of the complete orthogonal set were used. This practice was expedient because of the few degrees of freedom in the partitioned error terms which would have resulted in imprecise estimates of the errors. For example, the mean square for LT vs HT could have been tested against LT vs HT x locations mean square, with only one degree of freedom in the numerator and four degrees of freedom in the denominator. Instead, the mean squares for entries x locations with 24 degrees of freedom was used as the denominator in the F-test. This practice of expediency was not expected to vitiate the test.

Throughout the presentation and discussion of the data only those differences found to be significant at the .05 level of probability will be recognized as real differences.

The population rates were equally spaced independent variables. To study the trend of the dependent variable, yield, across the five rates, the linear and quadratic regression coefficients were computed by the method outlined by Le Clerg (1957). The cubic and quartic components are not considered to be of biological or agronomic importance. To facilitate the computation, the following orthogonal polynomial coefficients were used for the five rates:

	Plant population x 1000 plants per acre				
	12	16	20	24	28
Linear	-2	-1	0	+1	+2
Quadratic	+2	-1	-2	-1	+2

Linear and quadratic regression lines were fitted to the rate means of the combined data for entries using the following formula:

Linear $\hat{Y} = \beta_0 + \beta_1 \varepsilon_1$

Quadratic $\hat{Y} = \beta_0 + \beta_1 \varepsilon_1 + \beta_2 \varepsilon_2$

where $\hat{Y}$ = predicted yield at any given rate

β_0 = mean entry yield

β_1 = linear regression coefficient

B_2 = quadratic regression coefficient

ε_1 = orthogonal polynomial coefficients

Individual Crosses Field Procedures

The second set of hybrid trials had 64 entries consisting of the 61 selections and three checks, M14, C103 and M14 x C103 crossed to WF9 x 1205. The field procedures, sub-plot size, dates of planting and fertility and cultural practices were similar to the composite experiment. The planting details were as follows:

Plants/acre	Hills/sub-plot	Final plants sub/plot	Distance between hill inches
11,760	14	30	27.7
17,640	22	45	17.1
23,520	29	60	12.9

At the second rate, with perfect stand, one hill of the 22 was left with a single plant, in order that the rates be of equal increments. For purposes of convenience the planting rates will be rounded to 12,000, 18,000 and 24,000 plants per acre, and will be referred to as rate 1, rate 2, and rate 3.

Individual Crosses Statistical Procedures

The design at each of the three locations was three simple 8 x 8 lattices: one at each of the three rates. For each location two groups were selected from plan 10.5, page 430 Cochran and Cox (1957). The same group was used for replication 1 of all three rates, and the second group was used for replication 2. Different randomizations were used for each rate and different randomizations of rates within each replication. Different randomizations were used at each location.

The lattice analysis was used to calculate the entry means adjusted for block differences and error mean squares for each rate according to the procedures for simple lattice designs in the following form.

Source	D.F.	M.S.
Replications	1	
Entries (unadj)	63	
Blocks within reps (adj)	7	E_b
Intra-block error	49	E_e

The weighting factor used to obtain the adjusted treatment means was:

$$u = \frac{(E_b - E_e)}{8\ E_b}$$

The three simple lattices at each location were combined and treated as a split-plot, using rates as main plots and entries as sub-plots. A two-way table of the test-cross means was constructed to obtain the entry x rate interaction. In order to test this interaction a pooled average effective error mean square was calculated by pooling the errors for each rate.

For the analysis over locations, appropriate two-way tables were constructed to obtain interactions of entries x locations and entries x rates x locations. To test the two order interaction a pooled average effective error mean square was calculated in a similar manner as the pooled error for a single location. This error was not completely satisfactory because the individual location errors were heterogeneous at the 1% level but not at the 0.1% level of probability, as determined by Bartlett's (1937) test. This is expected to have some effect on the tests of significance and the results were therefore treated with caution.

Replications, rates and entries were considered to be fixed effects. In the analysis combined over locations, locations were considered to be random.

The form of the combined analysis with the expectation of mean squares was:

Source of variation	Degrees of freedom	Expectation of mean squares
Locations (L)	2	$\sigma_a^2 + rep\sigma_l^2$
Reps within L error a	3	σ_a^2
Rates (P)	2	$\sigma_b^2 + re\sigma_{pl}^2 + relK_p^2$
P x L	4	$\sigma_b^2 + re\sigma_{pl}^2$
Error b	6	σ_b^2

Source of variation	Degrees of freedom	Expectation of mean squares
Entries	63	$\sigma_c^2 + rp\sigma_{el}^2 + rplK_e^2$
E x L	126	$\sigma_c^2 + rp\sigma_{el}^2$
E x P	126	$\sigma_c^2 + r\sigma_{epl}^2 + rlK_{ep}^2$
E x P x L	252	$\sigma_c^2 + r\sigma_{epl}^2$
Pooled average effective error	440	σ_c^2

F-tests of significance of mean squares in the combined analysis were made as follows:

(a) the two order interaction and its orthogonal component were tested against the pooled average effective error, error c

(b) the entries x rates interaction and its orthogonal components were tested against the two order interaction

(c) the entries x locations interaction and its orthogonal components were tested against error c

(d) entries and its orthogonal components were tested against the entries x locations interaction

(e) the rates x locations interaction was tested against error b

(f) rates and its components, linear and quadratic, were tested against rates x locations interaction

(g) locations was tested against replications within locations, error a

In the analysis of variance, the degrees of freedom and sums of squares for entries and various entry interactions were divided into the orthogonal comparisons which were most relevant to this study, i.e., LT vs HT, LP vs HP, T vs P, E vs P + T and selections vs checks and others of lesser importance, viz., among E, among LT, among HT, among LP, among HP and among checks. Similarly the degrees of freedom and sums of squares for rates and the interaction of entries x rates were partitioned into rates linear and rates quadratic by the method outlined by Le Clerg (1957). As with the composite experiment, the pooled interactions with locations of the complete orthogonal set were used for the denominators in F-tests of the orthogonal comparisons.

The three population rates were equally spaced independent variables. To study the trend of yield across rates the linear and quadratic regression coefficients were computed in a similar manner as with the composite experiment, using the following polynomial coefficients.

	Rate 1	Rate 2	Rate 3
Linear	-1	0	+1
Quadratic	+1	-2	+1

Stability parameters for entries in the composite and individual line crosses were computed by the method of Eberhart and Russell (1965). The two parameters are: the regression of entries on environments indexed by grand mean yields at environments, and the squared deviations from this regression. In this present study each rate at each location was considered as a different environment. The composite study which was over five rates and five locations had 25 environments, while the individual crosses over three rates and three locations had nine environments. A stable variety according to Eberhart and Russell is one with b = 1.0 and the squared deviations, $S^2_{d_i} = 0.0$.

Only grain yield and moisture at harvest were subjected to the analysis of variance, but data on root and stalk lodging, per cent barren stalks and dropped ears were collected and studied for trends.

Inbred Lines Field Procedures

The agronomic performance of the inbred lines was studied in a split-plot experiment with five replications and two population rates as main plots. Entries, the sub-plots, consisting of inbred lines, were randomized within replications. In 1963 there were 38 entries; 18 F_7 lines which had been selected visually at the low population rate, 18 F_7 lines which had been selected visually at the high population rate, M14 and C103. In 1964 there were 63 entries: 3 F_7 E, 13 F_7 LT, 13 F_7 HT, 16 F_8 LP, 16 F_8 HP, M14 and C103.

A sub-plot consisted of a single unbordered row 220 inches long and 40 inches wide, with 16 hills spaced 13.3 inches apart. The lower rate of 12,000 plants per acre had one plant per hill and the higher rate had two plants per hill, giving it a density of 24,000 plants per acre. The seed was planted with an extra kernel per hill. The extra plants were thinned when the corn had reached a height of about 12 inches.

The following data are relevant to the performance of the experiment.

Year	1963	1964
Planting date	May 17	May 20
Previous crop	oats	oats
Fertilizer lbs./acre	80 N 35 P 16 K	80 N 18 P 16 K

Seed bed preparation and cultural practices were those normally accepted as desirable for corn production, with the supplementation of hand hoeing. The data taken included; yield, grain moisture at harvest, date of anthesis, barren stalks, and in 1964 plant height, stalk and root lodging and number of ears per plant, as well. After harvest, grain was sampled for moisture determination. In 1963 this was determined on a Tag-Heppenstall Electric Moisture Meter, and in 1964 on a Steinlite Electronic Moisture Tester. Plot yields were converted to cwt of shelled corn at 15.5% moisture, prior to determination of mean entry yields and analysis of variance.

The weather in 1963 in Iowa was conducive to above average corn yields. In 1964 the weather was less favorable but still about average. Detailed climatological data are presented in the appendix, Table 15.

Inbred Lines Statistical Procedures

Both gain yield and moisture data were subjected to analysis of variance in the following form.

Source of variation	Degrees of freedom 1963	Degrees of freedom 1964	Expectation of mean squares
Replications (R)	4	4	$\sigma_a^2 + peK_r^2$
Rates (P)	1	1	$\sigma_a^2 + reK_p^2$
R x P	4	4	σ_a^2
Entries (E)	37	62	$\sigma_b^2 + rpK_e^2$
E x P	37	62	$\sigma_b^2 + rK_{ep}^2$
Error b	296	496	σ_b^2

where r = number of replications

p = number of rates

e = number of entries

In the analysis of variance, the degrees of freedom and sums of squares for entries and the interaction of entries x rates were divided into the following orthogonal comparisons: LP vs HP, selections vs checks, among LP, among HP and among checks, in 1963, and in 1964, LT vs HT, LP vs HP, T vs P, E vs P + T, selections vs checks, among E, among LT, among HT, among LP, among HP and among checks.

RESULTS AND DISCUSSION

The composite experiment was designed for the evaluation of the groups of selections at different planting rates, when combined with the selection tester and with an unrelated tester of general combining ability. An estimate of the variability within the groups and the quality of individual lines in addition to group data was provided by the experiment of individual line crosses. Estimates of heritability, inbred - hybrid correlations and evaluation of lines as seed parents were provided by the inbred data.

Grain yields in the composite experiments averaged over the five locations are shown in Table 3. Individual location data and the analyses of variance for grain yields at each location are given in Tables 17, 19, 21, 23, 25 and 27 of the appendix. The entry means across rates in Table 4 were compared with each other in two ways: by the orthogonal comparisons in the analysis of variance in Table 4 under the category "entries", and by Duncan's Multiple Range Test in Table 3. The comparisons under entries were valid for selection groups when there were no corresponding entry interactions with rates or testers. Entry interactions involving locations were considered to be of secondary importance because the primary purpose of this study was to evaluate selection methods by the general merit of selections at random Iowa locations rather than detailed comparisons at specific locations. Individual location data would have been of interest only where gross differences in the relative performance among entries occurred. They did not occur.

The means obtained from entry sums across rates, testers and locations fell into two rough classes: LT, HT and HP, which were of similar merit, and LP along with the three checks, which had lower combining ability. Because neither LT vs HT nor LP vs HP interacted significantly with rates, some doubt is cast upon the veracity of the original hypothesis that selections from dense populations would do well in both low and high populations, but that selection from low populations would not do well in high populations. Under this hypothesis LT vs HT and LP vs HP should have interacted with rates, as the selections from high populations increased their advantage with increasing rates. In favor of the original hypothesis was the comparison of LT vs HT at the four lowest rates vs the same comparison at rate five. At the four lowest rates the comparison was in the favor of LT by 0.3 cwt, not a significant difference, while at rate 5 the comparison was in favor of HT by 2.8 cwt, which was significant ($p = .01$). Ht did not drop off in yield under population stress as sharply as did LT, as was reflected in the smaller negative linear regression coefficient, -2.26 for HT versus -2.67 for LT. Similarly, HP did not drop so sharply with increasing rates as did LP.

The only comparison which interacted with testers was M14

Table 3. Mean grain yields at five population densities averaged over two testers and five locations, mean yields with individual testers, regression coefficients, linear R_l and quadratic R_q, and stability parameters

Entries	Yield in cwt/acre (at rates x 1000) 12	16	20	24	28	Mean	D[a]	Tester 1 Mean	D[a]	Tester 2 Mean	D[a]	R_l	R_q	Stability parameters b	$s^2_{d_i}$
LT	57.9	62.6	60.3	56.2	47.7	56.9	a	58.8	a	55.0	ab	-2.67	-2.01	1.05	4.72
HT	59.6	59.9	60.7	55.5	50.5	57.2	a	58.7	a	55.8	ab	-2.26	-1.18	0.94	8.08
LP	57.1	58.5	59.0	50.2	45.7	54.1	b	55.4	ab	52.9	b	-3.12	-1.49	1.00	9.37
HP	59.1	63.2	62.1	52.7	50.0	57.4	a	58.2	a	56.6	a	-2.87	-1.56	1.01	5.13
M14	53.8	60.1	56.2	55.1	52.8	55.6	ab	54.6	b	56.6	a	-0.68	-1.01	0.78	13.08
C103	54.7	54.8	52.1	42.9	38.5	48.6	c	52.2	b	45.0	c	-4.43	-1.11	1.07	21.75
M14 x C103	56.5	59.1	58.3	50.3	44.8	53.8	b	54.4	b	53.1	ab	-3.22	-1.67	1.12	7.23

[a]Duncan's Multiple Range Test: entry yields with the same tester followed by common alphabetical letters are not considered to be different at the .05 level of probability.

Table 4. Analysis of variance for grain yields in cwt per acre for data combined over experiments 74-78, showing the orthogonal subdivision of the entry and rates compenents and of the interactions involving entries, rates and locations

Source	d.f.	SS	MS	F
Locations (L)	4	28926.09	7231.52	25.46**
Reps/L (Error a)	5	1421.36	284.27	
Rates (R)	4	15238.01	3809.50	26.75**
Linear (R_ℓ)	1	10535.31	10535.31	73.98**
Quadratic (R_q)	1	4073.19	4073.19	28.60**
Cubic	1	499.21	499.21	3.51
Quartic	1	130.30	130.30	0.91
L x R	16	2278.40	142.40	2.99*
Error (b)	20	949.51	47.48	1.71
Testers (T)	1	1039.20	1039.20	3.99
L x T	4	1039.54	259.89	9.36**
T x R	4	341.93	85.48	2.56
T x R x L	16	533.00	33.31	1.20
Entries (E)	6	5766.80	961.13	15.12**
LT vs HT	1	5.02	5.02	0.08
LP vs HP	1	542.85	542.85	8.54**
T vs P	1	171.87	171.87	2.70
Selections vs checks	1	2411.57	2411.57	37.95**
M14 vs C103	1	2444.40	2444.40	38.46**
M14 and C103 vs (M14 x C103)	1	191.08	191.08	3.00
E x L	24	1525.08	63.54	2.28**
LT vs HT	4	78.71	19.68	0.71
LP vs HP	4	218.79	54.70	1.97
T vs P	4	138.73	34.68	1.25
Selections vs checks	4	379.49	94.87	3.42**
M14 vs C103	4	389.95	97.49	3.51**
M14 and C103 vs (M14 x C103)	4	325.61	81.40	2.93*
E x R	24	2302.71	95.95	3.19**
E x R_ℓ	6	1525.12	254.19	8.45**
LT vs HT x R_ℓ	1	15.84	15.84	0.52
LP vs HP x R_ℓ	1	6.23	6.23	0.20
T vs P x R_ℓ	1	6.17	6.17	0.20
Selections vs checksxR_ℓ	1	49.89	49.89	1.65

Table 4 (Continued)

Source	d.f.	SS	MS	F
M14 vs C103 x R_ℓ	1	1389.80	1389.80	46.23**
M14 and C103 vs (M14 x C103) x R_ℓ	1	57.20	57.20	1.90
E x R_q	6	195.82	34.35	1.14
LT vs HT x R_q	1	80.69	80.69	2.68
LP vs HP x R_q	1	4.04	4.04	0.13
T vs P x R_q	1	1.26	1.26	0.04
Selections vs checks x R_q	1	40.33	40.33	1.34
M14 vs C103 x R_q	1	1.42	1.42	0.04
M14 and C103 vs (M14x C103) x R_q	1	68.08	68.08	2.26
E x R - Remainder	12	581.77	48.48	1.61
E x L x R	96	2886.31	30.07	1.08
E x L x R_ℓ	24	578.73	24.11	0.87
LT vs HT x R_ℓ	4	51.09	12.77	0.46
LP vs HP x R_ℓ	4	85.55	21.39	0.77
T vs P x R_ℓ	4	98.51	24.63	0.88
Selections vs checks x R_ℓ	4	53.51	13.38	0.48
M14 vs C103 x R_ℓ	4	233.25	58.31	2.11
M14 and C103 vs (M14xC103) x R_ℓ	4	56.82	14.20	0.51
E x L x R_q	24	820.47	34.19	1.23
LT vs HT x R_q	4	212.96	53.24	1.92
LP vs HP x R_q	4	193.58	48.39	1.75
T vs P x R_q	4	154.77	38.69	1.40
Selections vs checks x R_q	4	77.75	19.43	0.70
M14 vs C103 x R_q	4	149.73	37.43	1.34
M14 and C103 vs (M14 x C103) x R_q	4	31.68	7.92	0.28
E x L x R-Remainder	48	1487.12	30.98	1.12
E x T	6	1149.30	191.55	6.90**
LT vs HT	1	9.45	9.45	0.34
LP vs HP	1	11.85	11.85	0.42
T vs P	1	43.30	43.30	1.56
Selections vs checks	1	14.99	14.99	0.54
M14 vs C103	1	1033.30	1033.30	37.22**
M14 and C103 vs (M14 x C103)	1	36.31	36.31	1.30
E x T x L	24	1107.39	46.14	1.66*
E x T x R	24	767.45	31.98	1.15
E x T x R x Loc	96	3159.64	32.91	1.18
Error c	325	9020.08	27.75	
Total	699			

vs C103, indicating that the other comparisons may be made with yields averaged across both testers. On this basis, LT was similar to HT, HP was superior to LP, T was similar to P and selections were superior to checks. M14 was superior to C103 with both testers but the margin was greater with tester 2 and at higher rates (note M14 vs C103 by rates linear).

Bulking of groups such as LP and HP as P in the orthogonal comparisons resulted in gross comparisons which were unsatisfactory due to the confounding of intra-group inequalities and interactions with testers which were not detected by F-tests. Duncan's Multiple Range Test was a more satisfactory method of means separation. In this test it was considered useful to examine the entry means with one tester at a time because of the interactions of two of the checks with testers.

In crosses with the selection tester, tester 1, the means fell into two groups: the superior group included LT, HT, LP and HP, while the checks and LP fell into the inferior group. On the basis of Duncan's Multiple Range Test, LP was included in both groups. In crosses with the unrelated tester, the results were different in that no selection group was superior to M14 or M14 x C103. The test-cross of C103 was inferior to all the groups in the test. Inbred M14 combined better with tester 2, the groups of selections and C103 combined better with tester 1, and M14 x C103 had a similar performance with both testers.

The difference in the results with the two testers created a problem of which data to use for the evaluation of selection methods. The data from the selection tester, (tester 1) were useful in comparing the test-cross selected groups with (M14 x C103) x tester 1, since these groups had been selected on the basis of their performances with this tester. It is apparent from the comparisons of LT and HT with (M14 x C103) x tester 1 that progress was made during the three generations of selection by the test-cross procedure. For comparisons of accumulation of general combining ability, the Ia. 4810 data, tester 2, were expected to provide the better estimate because of the wide gametic diversity from this tester. The data showed some improvement for LT, HT and HP over M14 x C103, although the differences were not significant, and the full extent of the improvement for LT and HT with tester 1 was not realized for tester 2. On the other hand, HP was significantly better than LP, showing the advantage for visual selection at high stand levels. Neither tester has shown that any improvement was realized when visual selection was at a low population density.

Grain yield data and analysis of variance for the individual crosses experiment are presented in Tables 5 and 6 respectively. Because only one tester was used in this experiment there was no opportunity for the evaluation of entry x tester interaction. As in the composite experiment neither LT vs HT nor LP vs HP interacted with rates, but HT and HP had lower negative linear regression coefficients than LT and LP indicating that selection in dense populations resulted in lines which suffered less in population stress. Mean yields across rates and locations resulted in entry means which fell into three rough levels of combining ability. At the top was E, the three lines which in previous test-cross performance had been distinguished by superior yield in both low and high plant densities. A t-test of E vs HT, the second highest entry, indicated the difference to be significant (p = .01). In the second highest group were LT, HT and HP which among themselves differed by less than one cwt of shelled corn per acre. In the lowest group were LP and the checks. Unequal class numbers prevented the separation of entry means by Duncan's Multiple Range Test.

The E group showed very little difference in yield at the three different rates, in comparison to the other entries which showed considerable reduction from rate 2 to rate 3. This resulted in an interaction of E vs (P + T) with rates linear. Selections vs checks interacted with rates quadratic because of the more favorable response of selections to rate 2. This is evident in the margins of selections over checks at the three rates: 4.5, 7.3 and 3.5 cwt per acre, respectively.

The tests for among lines variances within E and LT, which were not significant, indicated that the lines within these groups were alike in their combining abilities, and their failure to interact with rates indicated that the lines reacted to rates according to group means. The among lines variances of HT, LP and HP were significant ($p = .01$) which suggested the individuality of lines within these groups. Several lines in LP which did not yield higher at rate 2 than at rate 1 or 3 resulted in significant variances of among lines x rates linear for this group. Significant variance for among lines x rates linear for the checks was due to the increase in yield of M14 x tester from rate 2 to rate three and a reduction in yield by the other two checks. Due to the failure of the lines within HP to have similar performance at rate 2 relative to their performance at rate 1 plus rate 3, there was a significant test of the variance due to among lines by rates quadratic.

The significant F-tests of the among lines mean squares for HT, LP and HP indicated that lines within these groups varied in their combining ability. More precise information was obtained by estimates of among lines variances which were derived from the expected mean squares for entries, $\sigma_c^2 + rp\sigma_{el}^2 + rplK_e^2$, and the expected mean squares for entries x locations, $\sigma_c^2 + rp\sigma_{el}^2$. Estimates of K_e^2, the variance due to entries, and its components, among lines variances, were obtained by dividing the difference between the two expected mean squares by the product of the coefficients rpl. The high among lines variance within LP suggested the existence of a high frequency of both inferior and superior lines relative to the quality of the mean. In Table 7 which shows the variance among lines within groups and the number of superior and inferior lines, this principle was demonstrated. The higher variances for the visually selected groups were associated with the higher frequency of poor lines, particularly in the case of LP. The frequency of superior lines was similar for all of the selection methods: five for T and five for P, five for low and seven for high rates (two lines were common to both rates in the E classification).

It appears that all of the selection methods resulted in similar numbers of superior lines, even though one of these methods, LP, seems like a collection of random lines from M14 x C103. The means of LT, HT and HP were superior to LP, not because of a higher frequency of superior lines, but because of a lower frequency of inferior lines; culling has been more effective than selection. Because of the small number of lines in these comparisons the preceeding comments are more in the nature of speculation than conclusion.

In the analysis of variance of the composite experiment the orthogonal comparisons involving interactions with locations showed no significant F values in spite of the wide range of mean yields among locations and the variation in the quantity and distribution of rainfall. In Table 6 one

Table 5. Mean yields (cwt/acre) at three population densities, linear and quadratic regression coefficients for selected lines and their ancestors crossed to WF9 x I205, averaged across three locations

	Yields cwt/acre at population densities (x1000)				Regression coefficients Linear R_ℓ	Quadratic R_q
Entries	12	18	24	mean		
E[+]	61.4	65.3	63.2	63.3	+0.90	-1.00
LT	59.4	63.0	56.5	59.6	-1.45	-1.68
HT	59.8	63.3	57.7	60.2	-1.05	-1.52
LP	58.0	61.0	53.7	57.5	-2.15	-1.72
HP	59.9	63.7	56.5	60.0	-1.70	-1.83
M14	50.7	50.2	54.8	51.9	+2.05	+0.85
C103	53.3	55.0	51.9	53.4	-0.70	-0.80
M14 x C103	60.0	60.4	51.4	57.2	-4.30	-1.57

Table 6. Analysis of variance for grain yields in cwt. per acre for data combined over experiments 79, 80 and 81, showing the orthogonal subdivision of the entry and rates components and of the interactions involving entries, rates and locations

Source	d.f.		SS	MS	F
Locations	2		26685.62	13342.81	29.74*
Reps/Loc. (Error a)	3		1345.81	448.60	
Rates (R)	2		7580.94	3790.47	7.64*
Linear (R_ℓ)		1	1653.52	1653.52	3.33
Quadratic (R_q)		1	5928.03	5928.03	11.94*
Locations x Rates	4		1985.31	496.33	0.91
Error (b)	6		3263.08	543.85	
Entries	63		18515.19	293.89	4.62**
LT vs HT		1	46.55	46.55	0.73
LP vs HP		1	879.42	879.42	13.82**
T vs P		1	342.75	342.75	5.39*
E vs (P + T)		1	800.07	800.07	12.57**
Selections vs checks		1	1435.42	1435.42	22.56**
Among E		2	91.56	45.78	0.72

Table 6 (Continued)

Source	d.f.	SS	MS	F
Among LT	12	939.32	78.27	1.23
Among HT	12	1861.00	155.08	2.44**
Among LP	15	8390.09	559.34	8.79**
Among HP	15	3431.95	228.80	3.60**
Among checks	2	274.51	137.25	2.16
Entries x Locations	126	8017.51	63.63	2.28**
LT vs HT	2	499.57	249.78	8.93**
LP vs HP	2	345.81	172.91	6.18**
T vs P	2	72.98	36.49	1.30
E vs (P + T)	2	360.43	180.21	6.44**
Selections vs checks	2	63.31	31.66	1.13
Among E	4	149.93	37.48	1.34
Among LT	24	1003.70	41.82	1.50
Among HT	24	1630.30	67.93	2.43**
Among LP	30	2165.80	72.19	2.58**
Among HP	30	1385.11	46.17	1.65*
Among checks	4	362.22	90.56	3.24*
Entries x Rates	126	8352.74	66.29	2.05**
Entries x R_ℓ	63	5431.08	86.21	2.67**
LT vs HT x R_ℓ	1	12.80	12.80	0.40
LP vs HP x R_ℓ	1	19.12	19.12	0.59
T vs P x R_ℓ	1	85.46	85.46	2.65
E vs (P + T) x R_ℓ	1	219.50	219.50	6.80**
Selections vs checks x R_ℓ	1	8.85	8.85	0.27
Among E x R_ℓ	2	11.00	5.50	0.17
Among LT x R_ℓ	12	574.66	47.89	1.48
Among HT x R_ℓ	12	599.17	49.93	1.55
Among LP x R_ℓ	15	2753.83	183.59	5.68**
Among HP x R_ℓ	15	903.31	60.22	1.86
Among checks x R_ℓ	2	243.38	121.69	3.77*
Entries x R_q	63	2747.14	43.61	1.35
LT vs HT x R_q	1	5.00	5.00	0.16
LP vs HP x R_q	1	4.64	4.64	0.14
T vs P x R_q	1	12.50	12.50	0.39
E vs (P + T) x R_q	1	49.41	49.41	1.53
Selections vs checks x R_q	1	134.48	134.48	4.16*
Among E x R_q	2	154.32	77.16	2.39
Among LT x R_q	12	395.09	32.92	1.05
Among HT x R_q	12	295.70	24.64	0.76
Among LP x R_q	15	723.33	48.22	1.49
Among HP x R_q	15	864.56	57.64	2.06*
Among checks x R_q	2	108.12	54.06	1.93
Entries x Rates x Locations	252	8265.56	32.80	1.15
Entries x Locations x R_ℓ	126	4634.48	36.78	1.32

Table 6 (Continued)

Source	d.f.	SS	MS	F
LT vs HT x R	2	86.84	43.42	1.55
LP vs HP x R	2	74.22	37.11	1.33
T vs P x R	2	252.30	126.15	4.51*
E vs (P + T) x R	2	142.97	71.49	2.56
Selections vs checks x R	2	31.80	15.90	0.59
Among E x R	4	199.26	49.81	1.78
Among LT x R	24	698.80	29.12	1.04
Among HT x R	24	1177.99	49.08	1.75*
Among LP x R	30	810.36	27.01	0.96
Among HP x R	30	1065.52	35.52	1.27
Among checks x R	4	94.43	23.61	0.84
Entries x Locations x R	126	3631.08	28.82	1.03
LT vs HT x R	2	27.02	13.51	0.48
LP vs HP x R	2	95.75	47.87	1.71
T vs P x R	2	64.06	32.03	1.14
E vs (P + T) x R	2	8.32	4.16	0.14
Selections vs checks x R	2	70.48	35.24	1.26
Among E x R	4	138.72	34.68	1.24
Among LT x R	24	747.35	31.14	1.11
Among HT x R	24	822.31	34.26	1.22
Among LP x R	30	968.60	32.29	1.15
Among HP x R	30	589.93	19.66	0.70
Among checks x R	4	98.54	24.63	0.88
Pooled average effective error	440	12309.38	27.98	

can see that in the individual crosses experiments there were interactions of important orthogonal comparisons with locations. At Ankeny LT and HT were similar in yield, but at Ames and Hampton they were not. At Ames LT was superior and at Hampton HT was superior. Less rainfall at Hampton in June may have favored HT relative to LT, while the abundant rainfall at Ames may have favored LT. A second factor which might have favored LT at Ames was two per cent less root lodging. Yield of HP was higher than LP at Ankeny and Hampton but not at Ames. Four per cent higher root lodging for HP at Ames

Table 7. Grain yields, among-lines variances, sources of the ten best and worst combining lines and Eberhart-Russell stability parameters for the individual crosses

Entries	No. of lines	σ^2_{lines}	Grain yield cwt	Ten best lines	Ten worst lines	Stability parameters regression coefficients b	deviations $s^2_{d_i}$
E	3	0.46	63.3	3, 10		0.85	16.03
LT	13	2.02	59.6	5	9	1.06	2.80
HT	13	4.84	60.2	6, 9	5	1.05	0.88
LP	16	27.06	57.5	2, 7	1, 2, 3, 4, 8	1.08	0.37
HP	16	10.15	60.0	1, 4, 8	6, 7, 10	0.90	1.13
All checks	3	2.60	54.2				
M14	1		51.9			0.66	29.18
C103	1		53.4			0.41	14.30
M14 x C103	1		57.2			1.24	16.60

may have reduced its potential advantage. At Hampton and Ankeny the elite lines were superior to the other selections but not at Ames, perhaps because these lines had 12% more root lodging than the other groups.

The reason for these location interactions of the individual crosses but not the composite crosses may be due to the greater genetic diversity of the composites. Rowe and Andrew (1964) studied genetically diverse segregating maize populations, and after examining the variety x environment components of variance proposed that compensating interactions of individuals within varieties or groups were responsible for their superior stability relative to genetically pure stands. In this study all of the hybrid yield plots contained genetically diverse individuals due to the segregation in the testers, but the diversity in the composite plots was greater due to the mixture of 16 crosses in each plot. Furthermore, in the composites, tester 2, a double-cross, supplied a greater diversity than tester 1, which was the only tester used in the individual crosses.

Eberhart and Russell (1965) developed a method of estimating stability parameters of varieties by their performance in a number of environments indexed by the mean yields of all entries in those environments. The response of individual varieties to different levels of environmental benignity is calculated as a regression of varietal yield on the index.

Both the regression coefficient and the deviations from regression are proposed as criteria of stability. As defined by these two authors, a stable variety is one with b = 1.0 and $S^2_{d_i} = 0$. The regression of 1.0 allows for a variety to respond to a favorable environment by an increase in yield, or to an unfavorable environment by a decrease in yield. Entries with b values lower than 1.0 might also be considered stable, but they may not be able to respond sufficiently to a benign environment. Deviations from the regression estimate the inconsistency of entry response to the range of indexed environments.

The stability parameters estimated for the composite and individual crosses experiments are presented in Tables 3 and 7. There were no significant differences among the b values, but some speculation appeared to be warranted. The stability of M14 x C103 was maintained in terms of deviations, and increased in terms of regression. In the composite experiment the regression of M14 x C103 in combination with the testers was 1.12, while for the selections it ranged from 0.94 to 1.05. In the individual crosses experiment the regression of M14 x C103 in combination with tester 1 was 1.24, while for the selection groups it ranged from 0.85 to 1.08.

Grain yields and other agronomic data were obtained for all inbred lines in 1964, and for the visually selected lines in 1963. Summaries of the grain yields by groups are shown in

Table 8, while more detailed data for individual lines are given in Tables 53, 54 (1963) and 55 (1964) in the appendix. The analysis of variance for yields in 1963 and 1964 (Tables 9 and 10) revealed highly significant differences between rates of plant stand, with rate 2 (24,000) being higher in both years. This was a contrast to the test-cross experiments at Ames in 1964 where the mean yield was higher at the 12,000 rate than the 24,000 rate. Selections as a group yielded more than the checks, but no group yielded significantly greater than M14 in either year. Group HP yielded more than group LP, and the margin was greater at rate 2. Also, the visually selected lines were superior to the test-cross selected lines, and the difference was greater at rate 2. Group E was similar to group P, but superior to group T. Highly significant differences among lines within groups were present in both years, and, except for E (1964), lines within groups did not behave similarly over rates. The implications of the among lines mean squares has already been discussed with reference to the individual line crosses experiment.

Table 8. Ranges, means, error variances and heritabilities[a] of inbred line yields at 12 and 24 thousand plants per acre

Entry		1963 Rate 1	1963 Rate 2	1963 Mean	1963 Range	1964 Rate 1	1964 Rate 2	1964 Mean	1964 Range
E	cwt grain					27.1	36.6	31.9	26 to 38
	σ^2 error								
	heritability								
LT	cwt grain					22.5	29.3	25.9	17 to 35
	σ^2 error					14.2	25.0		
	heritability					0.60	0.71		
HT	cwt grain					21.8	29.3	25.6	17 to 36
	σ^2 error					10.9	20.3		
	heritability					0.81	0.84		
LP	cwt grain	31.6	42.7	37.2	29 to 46	26.6	33.9	30.3	22 to 37
	σ^2 error	18.8	30.0			10.1	13.0		
	heritability	0.27	0.49			0.52	0.78		
HP	cwt grain	33.1	46.3	39.7	24 to 52	26.1	36.9	31.5	21 to 44
	σ^2 error	20.2	16.9			6.6	21.1		
	heritability	0.65	0.81			0.78	0.79		
M14	cwt grain	36.8	45.7	41.2		25.2	35.0	30.1	
	σ^2 error								
	heritability								
C103	cwt grain	17.2	20.3	18.7		12.9	11.4	12.2	
	σ^2 error								
	heritability								

[a]Heritability $= \dfrac{\sigma^2 \text{lines}}{\sigma^2 \text{lines} + \sigma^2 \text{error}}$

Table 9. Analysis of variance for inbred grain yield in 1963 for 36 visually selected lines from M14 x C103, and M14 and C103

Source	d.f.	SS	MS	F
Reps	4	830.62	207.65	5.46
Rates (R)	1	13248.81	13248.81	348.51**
Reps x Rates	4	152.06	38.02	
Entries	37	17298.48	467.52	22.77**
LP vs HP	1	572.54	572.54	27.89**
Selections vs checks	1	1347.70	1347.70	65.65**
Among LP	17	3172.65	186.62	9.09**
Among HP	17	9675.24	569.13	27.72**
Among checks	1	2530.35	2530.35	123.25**
Entries x Rates	37	2989.45	80.79	3.91**
LP vs HP x R	1	480.23	480.23	23.39**
Selections vs checks x R	1	193.45	193.45	9.42**
Among LP x R	17	889.41	52.31	2.55**
Among HP x R	17	1393.93	81.99	3.99**
Among checks x R	1	42.50	42.52	2.07
Error b	296	6075.46	20.53	
Total	379	40604.97		

Coefficient of variation 11.92%

Table 10. Analysis of variance for inbred grain yield in the experiment of selections from M14 x C103 and M14 and C103, 1964

Source	d.f.	SS	MS	F
Reps	4	98.54	24.64	
Rates (R)	1	10412.29	10412.29	127.09**
Reps x Rates	4	327.72	81.93	
Entries	62	31139.69	502.25	31.82**
LT vs HT	1	9.39	9.39	0.59
LP vs HP	1	118.83	118.83	75.29**
T vs P	1	3805.18	3805.18	241.13**

Table 10 (Continued)

Source	d.f.	SS	MS	F
E vs (P + T)	1	303.85	303.85	17.09**
Selections vs checks	1	1117.56	1117.56	70.82**
Among E	2	730.86	365.43	23.16**
Among LT	12	4388.37	365.70	23.17**
Among HT	12	9269.59	772.47	48.95**
Among LP	15	3150.95	210.06	13.35**
Among HP	15	6635.93	442.40	28.04**
Among checks	1	1609.22	1609.22	101.96**
Entries x Rates	62	5075.07	81.86	5.19**
LT vs HT x R	1	8.93	8.93	0.57
LP vs HP x R	1	234.27	234.27	14.85**
T vs P x R	1	142.89	142.89	9.06**
E vs (T + P) x R	1	12.79	12.79	0.81
Selections vs checks x R	1	81.42	81.42	5.16*
Among E x R	2	60.50	30.25	1.92
Among LT x R	12	699.01	58.25	3.69**
Among HT x R	12	735.43	61.29	3.88**
Among LP x R	15	1579.87	105.32	6.67**
Among HP x R	15	1359.80	90.66	5.74**
Among checks x R	1	160.18	160.18	10.15**
Error (b)	496	7829.61	15.79	
Total	629			

Heritabilities of the various groups were calculated according to the formula $H = \frac{\sigma^2 \text{lines}}{\sigma^2 \text{lines} + \sigma^2 \text{error}}$, and are presented in Table 8. In spite of the higher error variances at rate 2, heritabilities in this rate were higher due to the greater among lines variances. Except for HP vs LP in 1964, the groups selected in dense populations seem to have had lower error variances, indicating that they were more adaptable to small variations of environment. In addition to higher heritabili-

Table 11. Agronomic performance of lines summarized across rates and locations in 1964 for three experiments: composite (A), individual crosses (B) and inbred lines (C)

	E	LT	HT	LP	HP	M14	C103	M14xC103	Mean
% grain H_2O									
A		23.6	24.0	23.5	23.5	23.1	25.0	23.9	23.9
B	21.5	22.1	22.6	21.5	21.4	20.6	23.0	22.0	21.8
C	16.9	17.0	17.2	16.5	16.5	14.8	16.1	15.4[a]	16.7
Lodging									
root									
A		6.2	10.0	6.9	7.9	17.3	2.8	6.8	8.3
B	19.6	13.0	13.9	11.1	13.2	22.4	7.5	11.6	13.1
C	5.7	2.4	5.3	3.3	3.8	7.5	0.2	3.8[a]	3.8
stalk									
A		10.8	11.7	11.4	12.5	14.1	7.4	11.2	11.3
B	8.6	9.6	8.8	8.9	10.7	8.4	8.6	10.3	9.8
C	0.2	0.0	0.5	0.1	1.3	0.2	0.1	0.1[a]	0.3
Inbred height cm	137.7	142.7	140.3	124.7	141.6	123.0	150.0	136.5[a]	139.1
Dropped ears %									
A		4.4	3.6	4.8	5.2	3.2	6.2	4.5	6.4
B	2.8	3.6	3.9	4.1	4.5	2.7	3.1	4.2	4.0
Barren stalks %									
A		6.9	7.8	8.2	7.3	5.0	13.0	6.6	7.8
B	3.4	4.3	4.3	6.2	5.2	4.4	8.3	4.5	5.0
C	1.7	7.3	13.0	4.0	6.5	5.0	50.0	27.5[a]	7.3
Interval between silking and pollen shedding C	0.3	2.4	1.8	1.9	0.7	0.3	4.8	2.3[a]	1.8

[a]mean of M14 and C103

ties in rate 2, the correlations of inbred yield with hybrid yield at all locations and rates was higher for inbred yields at rate 2 than for inbred yields at rate 1 or rate 1 and 2 combined. These were; for rate 1, $r = 0.08$, for rate 2, $r = 0.25$ and for rates 1 and 2 combined, $r = 0.20$, all with 61 degrees of freedom. The correlation at rate 2 was significant ($p = .05$) but the other two were not. Differences among these r values were not significant. This higher correlation and heritability at rate 2 accounted for the more effective visual selection of inbreds at rate 2, resulting in the excellent HP group.

Individual inbred lines, especially from the visually selected groups, were exceptionally high yielding as inbreds per se. In 1963 at rate 2, yields in excess of 100 bu./acre were achieved by three inbreds averaged across five replications, and in 1964 again, by one of these inbreds. This yielding ability of inbred lines is a factor which should not be ignored by the corn breeder. A line of high combining ability which is difficult to maintain, or produces little seed as an inbred, can not be used economically as a seed parent for a single-cross because of the high cost of seed production. Single-cross seed is so valuable that the yield difference of five cwt/acre between the test-cross selected lines and the visually selected lines is worth $150.

An examination of agronomic characters other than yield,

Table 11, by group means in both sets of hybrid experiments and the inbred experiment revealed little information supporting meaningful differences attributable to selection methods. The grain moisture means of selection groups varied about 1% among each other within experiments; differences of little consequence. In the analyses of variance some comparisons had significant F-tests due to differences of small magnitude. With the exception of E, root lodging of groups within any location was similar. In the individual crosses and inbred experiments, E had about 50% more root lodging than the other groups, aggravated perhaps by the heavier ears. Stalk breakage among hybrids compared to selection groups varied by about 2%. In the inbreds there was a negligible amount of stalk breakage in terms of group means, although a few lines did have extensive stalk breakage. When compared to M14 x C103 in the hybrid experiments or the mean of M14 and C103 in the inbred experiments, the selection group means showed no improvement due to selection. This result was unexpected because during the years of selection, sufficient root and stalk lodging had occurred for selection pressure to be imposed. The failure of selection was probably due to the very small base population which was used, relative to the number of lines which were selected. The breeder was unable to impose sufficient selection pressure.

Selection for yield resulted in increased inbred plant heights in LT, HT and HP. Where selection was ineffective, LP, height was slightly reduced, 12 cm below the mean of M14 and C103. Perhaps in low populations a spreading type of growth might make more efficient use of the light than a vertical type of growth. Although E was markedly superior in combining ability to the other selection groups, its increase in plant height was a scant 1.2 cm.

Yield improvement in the hybrid experiments was not noticeably associated with reduction in the frequency of barren stalks. The selections did not have a lower frequency of barren stalks than (M14 x C103) x testers. In the inbreds all selection groups were better than the mean of M14 and C103. Heritability of barreness in the inbreds must have been high, but the correlation of inbred - hybrid barreness, low.

Delayed silking relative to pollen shedding could be a yield factor, especially with respect to C103 and other lines in which silking was permanently delayed. Availability of pollen may not have been a decisive factor in barreness and yield reduction since it was available from the various entries and adjacent experiments, but under conditions of pure stand of inbreds or single-cross hybrids, pollen availability for delayed silks might be a serious factor in yield reduction. The approximate two day pollen shedding - silking interval of LT, HT and LP in the inbreds was similar to the parental mean, but E and HP were similar to M14, with a half day interval. The E and HP groups also had less barreness, suggesting that this characteristic is a function of delayed silking.

These experiments were designed to compare the effectiveness of the various selection methods rather than their efficiencies. To compare the effectiveness, the base population size and the selection pressure were held constant. This procedure did not allow for a comparison of efficiency because the investment of resources was not held constant for selection systems, and the cost of genetic advance for each method was difficult to estimate. Furthermore, the restriction of F_2 population size, which was necessary due to the prohibitive cost of testing, handicapped the visual selection systems, which are most efficient with large populations and intense selection pressure. A second factor which must be considered is the accumulation of general and specific combining ability. Lines developed by visual selection are expected to have high general combining ability, in contrast to the test-cross derived lines which were developed and selected for specific combining ability with the tester only, and therefore may lack in versatility. The visually selected lines could be expected to combine well with a wider diversity of genotypes and may be tested for especially favorable specific crosses. One must consider these factors in order to extrapolate from effectiveness comparisons to efficiency comparisons.

The performance of HP compared very favorably with the test-cross groups, even without making allowances for the specific combining ability of the latter in combination with the selection tester. In Table 11, comparisons of HP with the checks in the hybrid experiments provided no evidence that the superiority of HP combining ability was achieved by the reduction of obvious plant defects such as barreness or lodging. If this observation reflects a true relationship between the lines and checks and if HP was superior in combining ability to a random sample of lines which could have been inbred from M14 x C103, then selection for general vigor rather than against obvious plant defects was responsible for a remarkable improvement of combining ability.

If the apparent remarkable success of the visual selection program was real, then it was due to the perspicacity of W. A. Russell, who, working with only moderate correlations of inbred - hybrid performance, was able to discriminate those nebulous qualities in the inbreds usually described by the vague term "general vigor." Visual selection for general vigor could only have been effective in the hands of an experienced and perspicacious breeder.

The results of these experiments raised two interesting questions. How can visual selection of lines in dense inbred stands be as effective in producing lines of similar combining ability in crosses with a specific tester as selection by test-cross performance with that same tester; and how can selection in dense stands result in lines which perform well across a range of rates, while selection in low densities results in lines which suffer more under population stress?

Falconer (1952) suggested a hypothesis which can explain these results. Situations involving interactions between genotypes and environments can be treated by methods of genetic correlation if only two environments are considered, i.e., low and high population densities, or inbred and hybrid genetic environments. Performance in the two environments are regarded as two different characters which are genetically correlated. Selection for one character brings about the correlated response of the other character, the magnitude of which may be greater than the direct response, where a high correlation is accompanied by higher heritability in the selection environment. The ratio of the correlated response can be expressed in a simple formula involving the square roots of the two heritabilities and the genetic correlation.

This present study indicated that test-cross performance in low and high rates were highly correlated. Nine F_2 plants had descendants in both LT and HT. There was little or no correlation between performance in the low and high rates of the inbred visual selections, because LP and HP shared only three F_2 in common. Inbred performance at rate 2 was correlated with test-cross performance because in the yield trials HP, which performed well as inbreds in high populations also performed well in test-crosses.

Testing in two population densities, though not as extensively as in the development of these lines, may be justified by the correlation between performance in the two population densities in the test-crosses and the superb behavior of group E. Much, if not all, of the advance of selections over checks was made during the first generation of testing (see Table 1). Two years of testing at two population densities following extensive and intensive visual selection is a worthy consideration. Diligence in visual selection during the early generations of inbreeding should result in lines which are easy to maintain, high yielding as seed parents and of high combining ability. It is expected that as the vigor of the inbred lines improve the requirements for top-cross tests will be reduced; for general combining ability which is measured in top-cross tests, and the performance of inbred lines *per se* are both governed by the additive gene action of lines, and can be expected to be highly correlated. Inbred lines of low vigor are poorly correlated with top-cross performance because of their greater sensitivity to environment and because of recessives with major deleterious effects which mask the expression of other, favorable genes.

If top-cross tests do actually become obsolete, the resources which are released can be invested in the increase of initial population size.

A factor which is worth considering in a program relying heavily on visual selection for combining ability is visual evaluation at two population rates, and selection of those lines which are superior at both rates. Individual plants, of F_2 progeny which had been superior at both rates, would be selfed and the resulting seed again be grown at both rates. For how many generations selection within progeny rows is profitable is not certain, but the efficacy diminishes very quickly with advancing generations, and the point is soon reached where there is so little genetic variation within rows that selection is ineffective. Between row selection also becomes more difficult as the variability is reduced; however, the negligible cost of visual selection would permit it to be profitable with even a small margin of return.

Environment is an important factor in the effectiveness of selection. A favorable environment in an early generation might minimize the number of years of selection. A sequence of years in which the desired character is not expressed might result in an extended number of generations and years before the final selection can occur.

The rates at which the inbreds should be planted is another problem. It appears that a rate of 12,000 plants per acre is not sufficiently dense. Although visual selection at 24,000 plants per acre was the better in this study, this may not be the optimum rate at which to select lines for improved combining ability. Further research is necessary to determine the optimum population density for maximum heritability.

The results of this study are consistent with those of Ferguson's (1962) in many respects. We both found that lines selected for superior performance in high rates were superior at both low and high rates, but that lines selected in low rates showed a greater yield reduction in dense populations. We differed, in that he found no change in entry rank from rate to rate, while in this experiment the checks interacted with rates due to a change in rank. The three elite lines in this experiment behaved similarly to Ferguson's High x Low crosses. Both were superior to the other groups at all rates and showed less yield reduction under the stress of dense population. Ferguson ascribed this pehnomenon to a heterotic effect, but in the case of the E group I believe that gene action other than dominance or overdominance must be considerable, because of comparable manifestations of this phenomenon in the inbred experiment.

Sprague and Miller (1952) evaluated the effectiveness of visual selection for combining ability in a population density of 12,000 plants per acre. Two sets of S_0 plants were selected through five generations, and the resulting inbred lines crossed in all possible combinations. Very little change in combining ability was observed across generations. These results were similar to those of this present study, where selection at 12,000 plants per acre, by visual means, was ineffective in improving combining ability.

Lonnquist (1950) found that selection in generation beyond S_1 (equivalent to F_2 in the degree of inbreeding) was effective in improving the combining ability of S_1 families. The comparisons of selections vs checks in Table 1 of my study, although not strictly comparable to the data cited by Lonnquist, did indicate that little or no advance was accrued after the first generation of testing and selection.

Richey (1945) also predicted that in more advanced generations, with the elimination of recessives of major importance, selfs and crosses will tell more nearly the same story. This prognosis was supported by the excellent hybrid performance of lines selected on the basis of phenotypic appearance compared with the test-cross performance of the selected lines. He also remarked of Jenkins' data, that visual selection would have had similar success to early testing, and at a much lower cost. These remarks were true of this present study.

Further evaluation of the studied lines are warranted by the results of these experiments, but under somewhat different conditions.

Separation of the elite lines in a composite experiment is justified by their unique performance in the individual crosses and inbred experiments. Their uniqueness had not been fully anticipated prior to the experimental results, with the consequence that no provision had been made for their evaluation in the composite crosses.

A second occurrence which had not been anticipated or desired was the interaction of checks with testers, visual selections vs checks with testers, and the absence of an interaction of test-cross selections vs visual selections with testers. The interaction of checks with testers obfuscated only the among checks comparisons which are of secondary importance, but the interaction of visual selections vs checks obscured a comparison of major importance; a comparison which was the evaluation of the effectiveness of visual selection in producing lines of higher combining ability than the original source, M14 x C103. The favorable combination of Ia. 4810 with M14 x C103 relative to the visual selections contradicted the results obtained in crosses with WF9 x I205. One may infer from this that there was a considerable presence of specific combining ability which obscured the desired comparisons of visual selections vs M14 x C103 in terms of general combining ability. Two ideal testers would have resulted in similar relative comparisons.

Dissimilar comparisons of test-cross selections vs visual selections with the two testers were anticipated but not detected by F-tests, although examination of the data revealed the expected trend. The difference between the test-cross selections and checks with the non-selection tester was less, as was expected, but the already noted favorable combination of M14 x C103 with Ia. 4810 was sufficiently disturbing that the results with these testers were accepted with some reservations. Subsequent studies of these selections in a composite type of experiment might include one or two additional double-cross testers to provide more lucid results.

In view of the consistent response of the important entry comparisons across the range of locations and rates in the composite experiments, as Ferguson (1962) also found, and of the similar combined experimental data of the individual crosses, future studies of this material might be more economical in composites at only three locations and rates of 12, 18 and 24 thousand plants per acre. This would reduce the number of plots by 64%, or would allow for tripling the number of testers with only a few per cent more plots.

The rate at which improvement occurred during the selection program is of great interest, in view of the earlier reports by Richey (1945) and Lonnquist (1950). Comparisons of selections vs checks in Table 1 indicate that much, if not all, of the advance of the test-cross selected lines were made in the first generation of selection, but these comparisons may be confounded with year interactions and are therefore inadequate. Remnant seed could be used to obtain crosses, of all selections of each generation, to both the selection tester and one or more sutiable unrelated double-cross testers. These crosses could be entered in a composite type of yield trial in order to restrict the total number of plots to a manageable quantity, and because of the relative unimportance of the information which would be lost in the compositing.

The failure to detect a marked reduction of barren stalks in hybrids of selections from dense stands was an unexpected occurrence. In the F_3 of the visually selected lines in high stands there was extensive elimination of lines which showed delayed silking or barreness. Similarly, the test-cross selections were tested in a number of stress environment, i.e. the drouth of 1956, which should have resulted in the elimination of lines most susceptible to barreness under stress. Indeed, there was a marked improvement of E and HP in regards to delayed silking, the most common cause of barreness, and a reduction of barreness in inbreds E, LP and HP relative to the mean of M14 and C103, but when measured by counts of earless stalks of hybrids no improvement was evident. A plot count of the number of the harvested ears rather than the counting of plants with no apparent ear formation as was done in the composite and individual crosses experiments, would have given more accurate data on barreness.

Although there were a number of two-ear type lines among the inbreds, there was no correlation of two earedness with combining ability. The 10 highest combining lines had virtually the same average ear number per plant at both inbred rates as the grand mean of all of the selections. The two lines which had the highest average ear number per plant were not among the 10 highest combining lines.

PART II. EAR SHOOT DEVELOPMENT OF INBRED LINES

REVIEW OF LITERATURE

The developmental pattern of the corn plant has been reviewed by Weatherwax (1955) and Sass (1955) from the botanical aspect of developmental morphology. Shaw and Loomis (1950) reviewed previous findings in this field in relation to agronomic interests. They divided the development of the corn plant into five distinct stages, of which the second stage is relevant to this present study. This stage is defined by them as the rapid vegetative growth from a plant height of about 50 cm. to silking.

At the beginning of this period the tassel is microscopically visible at or below ground surface level. Culm development is still embryonic, but the maximum numbers of leaves, vascular bundles, ear shoots and ovules are already determined by early June. Previous to this period weather is seldom a limiting factor and recovery from early serious setbacks is usually almost complete. Developmental studies prior to this stage are therefore not expected to yield data of agronomic interest.

Ear shoot development was noted as an important and vulnerable phase. Temperature above 90^{o}F retards development, particularly when accompanied by moisture stress. Unfavorable conditions just preceeding tasseling result in a high incidence of barren stalks. Before fertilization the ear shoot is weak in its ability to compete for food: afterwards foods move to the ear shoot at the expense of the rest of the plant, even to the point of root and leaf starvation and necrosis.

Sass (1960) observed that the morphological differences between the two top ears in a one ear, yellow dent hybrid were not apparent until 68 to 71 days following planting. After this period the failure of second ear formation was due to factors associated with competition prior to and after anthesis. Sass and Loeffel (1959) found that the formation of floral organs in maize is not prevented by dense planting. Competitive pressure does not produce a marked reduction in ear elongation, ovary development or silk elongation until 74 days after planting. Barrenness was due to the failure of silk emergence during the pollen shedding period.

Sowell, Ohlrogge and Nelson (1961) concluded that barrenness was due to the competition between vegetative growth and ear shoot development for the limited resources of the plant. Compact mutants of inbred Hy were able to produce grain under conditions of population stress due to the termination of vegetative growth at an early stage of plant development. Normal Hy does not cease vegetative growth at the time of ear shoot development and in dense populations this results in barrenness.

Collins (1963) studied ear shoot development in inbreds C103, Hy, R71 and B60 and the six possible single-crosses among these four lines. Inbreds C103 and Hy usually produce only one ear, and R71 and R60 usually produce two harvestable ears. All genotypes which showed retarded second ear growth during the three days prior to silking failed to produce second ears. In general, both first and second ear shoots of Hy, C103 and the cross between these lines showed a retarded growth rate, which became apparent about nine days prior to silking. He concluded from these data that the degree of second ear development in this early stage is an aid in detecting two ear types, particularly those which ultimately fail to produce a harvestable second ear.

Balint and Furedi (1961) found that the enhancing effect of light, heat, spacing and nutrients upon ear development and hence upon yield vary as a function of variety and individual plant characteristics.

Levanova (1955) and Giosan _et al_. (1961) observed an association between morphogenesis of the ear shoot and maturation. These authors found that early maturing varieties are distinguishable from late varieties by their earlier differentiation of axillary buds and quicker rate of ear formation.

MATERIALS AND METHODS

In 1963, 36 F_7 visually selected lines, M14 and C103 were planted in a randomized unreplicated experiment at the Agronomy Farm near Ames. A plot consisted of a single row 110 feet long and 40 inches wide. The single plant hills were spaced 13.3 inches apart. With a perfect stand the population density was 12,000 plants per acre. Hills in which the seed failed to germinate, or seedling did not survive, were replanted with purple inbred corn to provide the adjacent plants with competition.

Extraction and measurement of ear shoots was begun on July 9, three weeks before the anticipated date of silking, and repeated approximately every second day until each line had 50% or more of the remaining plants in the plot silking. The length measurements on this day were the last for that particular line.

An observation was made by taking five bordered plants from a plot, extracting the two top ear shoots from each plant and averaging the cob lengths of the five top cobs and the five second cobs, respectively. The extraction technique consisted of slitting both flat sides of the culm with a knife from crown to apex, stripping off the leaves to expose the prophylls and removing the top two prophylls. The two prophylls were opened by a longitudinal incision which exposed the cobs for measurement.

In 1964 all the inbreds which were entered in the inbred yield trials were also entered in this experiment for the study of ear shoot length development. The field design was a randomized complete block with three replications. Plot size was reduced to half; 1/240 acre. An area adjacent to this inbred experiment was planted to M14 x C103 to provide a comparison of the inbreds with their single-cross progenitor, without exposing them to the superior competitive advantage of a hybrid.

In 1964 only three plants per replication were sampled at each observation. The final observation of each line in both years was ten plants, or as many as available up to 10 per replication, in order to make the final value as precise as possible. Using the final date of sampling for each line, 14 days earlier became day one, 13 days earlier became day two, and so on, to provide a coded calendar based on the lines' organogeny. The data of lines of common selection method were bulked to minimize erratic trends due to small sample size.

The 1963 season was excellent for corn production, with generally adequate moisture supply. There was a shortage of soil moisture for several days in late June, but this was relieved two weeks in advance of the first observations. The 1964 season was excellent from the date of planting until the termination of the experiment. Detailed climatological date are presented in the appendix.

The following data are relevant to the performance of the experiment.

Year	1963	1964
Planting date	May 9	May 4
Date of first observation	July 9	July 8
Previous crop	oats	oats
Fertilizer lbs./acre	80 N 35 P 16 K	80 N 18 P 16 K

RESULTS AND DISCUSSION

As with the Collins (1963) study, the most fruitful information of cob elongation phenomena was obtained during the two weeks preceeding silking. The current data closely approximated a semi-logarithmic curve; log ear length versus time. Table 12 contains the coefficients of determination for the selections and the checks. Since over 90% of the growth can be explained by the semi-logarithmic relationship, the raw data were converted to the semi-log form for presentation and analysis. The single major exception to the otherwise consistent pattern was the second ear of C103 in 1964 which failed to develop as it did in 1963.

Table 12. Coefficients of determination for the inbred selections, M14, C103 and M14 x C103 for the relationship log ear length versus time, for the two top ears during the two weeks preceeding silking

Entry	1963 Top cob	1963 Second cob	1964 Top cob	1964 Second cob
E			.82	.83
LT			.91	.90
HT			.94	.92
LP	.98	.93	.89	.87
HP	.98	.98	.97	.94
M14	.98	.98	.92	.88
C103	.96	.86	.81	.47
M14 x C103			.95	.94
All selections			.94	.91

The growth rate of the entries in terms of their regression coefficients is presented in Table 13.

Table 13. Regression coefficients, b, of log cob length with time for the two top ears during the two weeks preceeding silking, and cob length at date of silking.

Entry	1963 Top cob b	1963 Top cob length cm	1963 Second cob b	1963 Second cob length cm	1964 Top cob b	1964 Top cob length cm	1964 Second cob b	1964 Second cob length cm
E					.071	12.9	.073	10.2
LT					.063	13.5	.052	6.8
HT					.062	13.3	.051	6.9
LP	.078	12.8	.072	8.5	.076	13.4	.068	8.0
HP	.074	13.5	.071	9.4	.068	13.6	.064	7.9
M14	.066	12.2	.057	8.1	.082	12.5	.075	8.4
C103	.085	12.5	.055	2.5	.059	10.4	.025	1.5
M14 x C103					.066	16.4	.058	8.7
All selections	.076		.065		.070	13.4	.060	7.6
3 highest combiners					.073	15.2	.070	8.7
3 lowest combiners					.066	13.6	.046	8.9
Standard error S_b	.004		.005		.008		.022	

An analysis of variance of the regression coefficients, Table 14, indicated that the differences among b's in 1963 were not significant but that in 1964 the differences among b's for both top and second cobs were significant (p = .01).

The three lines which were the highest combiners at Ames in the individual crosses had only average growth rates of the top cobs but very high growth rates of the second cobs. High growth rates of either or both ears did not necessarily result in high combining ability. The LP had above average growth rates for both cobs but had mediocre combining ability as a group. Low growth rate was not always associated with low combining ability as demonstrated by HT which had low growth rates for both ears but also had high combining ability. The hybrid vigor in the single-cross M14 x C103 did not express itself in a faster growth rate of either ear. Its greater cob length at date of silking was probably due to the earlier commencement of cob development.

In 1963 the ear length at silking date was found to be correlated to inbred yield with r = 0.45. Shaw and Loomis (1950) found higher correlations, circa r = 0.90, for hybrid ear length at harvest with grain yield. Thus ear measurements may be a way of inbred evaluation which is less expensive than harvesting and weighing.

Table 14. Analysis of variance of regression coefficients of log ear length on time for the two weeks prior to silking

Source	d.f.	SS	MS	F
<u>1963 top ears</u>				
Regression	4	4.30		
Deviations from regression	29	0.10		
Total	33	4.40		
$\bar{b}$	1	4.27	4.270	1,257.94***
Among b's	3	0.03	0.010	2.88
Deviations	29	0.10	0.003	
<u>1963 second ears</u>				
Regression	4	3.14		
Deviations from regression	29	0.18		
Total	33	3.32		
$\bar{b}$	1	3.09	3.095	499.22***
Among b's	3	0.04	0.014	2.26
Deviations	29	0.18	0.006	

***F significant at the .001 level of probability

Table 14 (Continued)

Source	d.f.	SS	MS	F
<u>1964 top ears</u>				
Regression	7	7.77		
Deviations from regression	76	1.23		
Total	83	8.69		
$\bar{b}$	1	6.98	6.980	430.81***
Among b's	6	0.79	0.131	8.10
Deviations	76	1.23	0.016	
<u>1964 second ears</u>				
Regression	7	6.02		
Deviations	76	0.92		
Total	83	6.95		
$\bar{b}$	1	5.66	5.659	467.72***
Among b's	6	0.36	0.060	5.00**
Deviations	76	0.92	0.012	

**F significant at the .01 level of probability

SUMMARY AND CONCLUSIONS

The purposes of this study were to:

1. test the hypothesis that lines selected by performance in high population rates will be superior at both low and high population rates, but that lines selected in low population rates may not be superior in high population rates.
2. compare the effectiveness of visual selection with that of selection by test-cross performance for the production of lines superior as inbreds and in hybrid combinations.
3. observe the pattern of ear shoot elongation of the selected lines during the two weeks prior to silking, and relate these patterns to selection methods and combining abilities.

The lines under study were selected from F_2 of M14 x C103 by four methods: selection by test-cross performance in low and high population rates, designated as LT and HT respectively, with E representing three lines which were superior at both rates, and selection by visual evaluation of inbred lines in low and high population rates, LP and HP respectively.

Four sets of experiments were grown: two test-cross experiments in 1964 at three and five locations respectively, and two inbred experiments in which the inbreds selected visually were grown in 1963 and all of the inbreds were grown in 1964, at a single location. The hybrid characters studied included grain yield and moisture at harvest, incidence of barren stalks, root znd stalk lodging. Inbred characters studied included grain yield and moisture at harvest, date of anthesis, plant height, incidence of barren stalks, root and stalk lodging, and developmental patterns of the first and second ears for the two weeks prior to silking.

In the hybrid experiments LT vs HT and LP vs HP did not interact with rates, indicating that selection at either population density produced lines with similar response to rates. This conclusion was placed in some doubt because at the highest planting rates in each experiment the groups selected in dense populations were always superior to the groups selected in low populations while this was not necessarily true at the other rates. Furthermore, the negative regression coefficients were smaller for the groups selected in dense populations indicating a lower yield reduction under population stress for those lines selected for their performance in dense populations. For these reasons the tentative acceptance of the original hypothesis is warranted: lines selected on the basis of their performance in dense populations are also superior in low population densities, but lines selected on the basis of their performance in low populations are not necessarily superior in dense populations.

Because the comparison of test-cross selected lines versus visually selected lines did not interact with testers in the composite experiment there was no confirmation of the accumulation of specific combining ability. Had evaluation by test-cross performance been successful in the accumulation of specific combining ability relative to the selection tester, one would have expected a more favorable comparison for the test-cross groups when in combination with the selection tester. This was actually the case, but the difference was not sufficient to be statistically significant.

A comparison of group means indicated that selection was effective for E, LT, HT and HP because their means were superior to M14 x C103 from which they had been selected. The mean of LP was not superior to the single-cross. The mean yield of E at the three rates did not differ very much, indicating stability which might be expected to exist not only for population rates but other environments such as years and locations. The group among-lines variances indicated wider variability within the visually selected groups. These groups had higher frequencies of extreme lines inferior and superior relative to the mean. The sources of the ten highest combining lines were: two from E, one from LT, two from HT, two from LP and three from HP. Because of the small numbers these differences are not significant, and we might conclude that in terms of the production of high combining lines there were no apparent differences due to selection method.

Those agronomic characters which were studied in the inbred and hybrid experiments showed little differences due to selection methods. The range in root lodging of the groups varied by only a few per cent, with the exception of E which had about 50% more than the other groups. Compared to M14 x C103 there was no improvement in root or stalk strength. Inbred plant height was increased over the mean of the checks.

The inbred grain yield of the visually selected lines grown at 12,000 and 24,000 plants per acre was 120% of the lines selected by test-cross performance at a single rate. LT was similar to HT, and LP was similar to HP at the low rate, but at the high rate HP was superior to LP. This latter comparison supported the hypothesis previously mentioned. The three E lines were similar to HP in grain yields as inbreds, even though they had not been selected for inbred performance. The among-lines mean squares for all groups indicated the presence of significant variability within the groups, and the wisdom of evaluation of individual lines in addition to group comparisons. The among-lines mean squares for all the groups, except E, interacted with rates, reflecting the individuality of line response to rates. The three E lines had similar responses to rates.

Heritability in the narrow sense was higher in the dense rate in spite of the increased error, due to the greater among-lines variances. Inbred yields at the dense rates were more highly correlated with hybrid yields at all rates and locations than inbred yields at the low rate. This higher heritability was reflected in the superior mean performance of HP over LP, both as inbreds and as hybrids. The higher heritability in the dense rate was due to the higher among-lines variance and in spite of the increased error at the high rate.

The growth rate of the two top ears during the period studied closely approximated a semi-logarithmic curve, log ear length versus time. The three lines which had the highest combining ability at Ames were scarcely above average in growth rate of the top cob but had very high growth rates for the second cob. The three lowest combining lines were only slightly below average in growth rates of the top cob but had very low growth rates of the second cob. The second ear shoots were, therefore, a more sensitive gauge of combining ability than the top cobs. The growth rates as measured by the regression of log ear shoot length on time were subjected to analysis of variance. There were no significant differences among groups in 1963, but in 1964 the differences were significant ($p = .01$). E, LP and HP had higher growth rates than LT and HT, but ear lengths at silking were similar, indicating earlier growth initiation in the latter. The second cobs of E were much longer at silking date than even those of M14 x C103, a hybrid. The hybrid vigor of the single-cross did not express itself in the faster growth rate of either ear shoot, but rather in the earlier commencement of cob elongation. LP and HP had longer second ears than LT and HT, reflecting the higher inbred vigor of the visually selected lines. Second ear growth rate and its length at silking are gauges of the vigor of inbred lines and can be used for rough estimation of combining ability.

Selection by visual evaluation of inbred line performance in dense stands was at least as effective as selection by extensive test-crossing, and far more efficient. The expenditure of time and treasure were far less for visual selection. This method might possibly be improved by visual evaluation at two populations and selection of only those lines which perform well at both rates. As the vigor of the inbred lines improves, the measurement of general combining ability by topcross tests may be partially or completely replaced by inbred line performance, at a much lower cost.

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APPENDIX

Table 15. Rainfall and mean temperature at the Agronomy Farm near Ames, Iowa for May, June, July and August 1963 and 1964, and for outlying locations in 1964

		Rainfall - inches				Mean temperature °F			
Location	Year	May	June	July	August	May	June	July	August
Ames	1963	3.88	2.45	7.33	5.92	60.2	73.5	74.2	70.1
	1964	4.07	7.71	4.34	3.14	65.8	69.1	75.6	68.3
Ankeny	1964	3.61	7.12	2.85	4.04	67.6	70.3	76.6	70.1
Hampton	1964	2.84	2.47	8.38	3.93	64.4	69.1	75.0	67.8
Newell*	1964	3.14	3.79	4.38	3.43	61.1	66.4	73.4	65.4
Sheldon	1964	2.63	2.74	6.39	3.91	63.0	68.9	75.9	67.4

*these data are taken from Storm Lake which is the closest weather station to Newell

Table 16. Agronomic data of 4 composites from 61 selections out of M14 x C103, and 3 checks, in test-cross performance with two testers, T_1 and T_2, grown near Sheldon, Iowa, 1964, showing linear and quadratic yield regressions, R_ℓ and R_q across population rates

Entry	Yield - cwt per acre at rates (1000 plants/acre) 12	16	20	24	28	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at 24	28
LT T_1	56.5	60.3	55.8	54.0	43.8	54.1	-3.17	-1.81	25.5	1.7	5.2
HT T_1	62.6	54.5	55.9	56.4	48.6	55.6	-2.61	-0.02	25.9	4.2	6.4
LP T_1	55.6	57.8	60.9	53.6	46.6	54.9	-2.22	-2.06	24.6	3.4	5.2
HP T_1	58.8	58.1	63.4	48.8	48.7	55.6	-2.95	-1.34	24.3	1.7	1.5
M14 T_1	52.0	56.5	54.1	59.6	49.3	54.3	-0.23	-1.55	24.5	0.0	3.2
C103 T_1	54.5	55.1	49.3	42.9	41.6	48.7	-3.80	-0.31	26.3	9.1	7.6
M14 x C103 T_1	53.6	56.3	58.2	46.2	39.9	50.8	-3.75	-2.28	25.0	4.3	6.1
LT T_2	54.7	55.3	59.4	54.8	44.1	53.7	-2.17	-2.23	25.5	5.9	4.5
HT T_2	56.1	52.6	52.1	56.3	54.9	54.4	+0.13	+0.64	26.8	1.7	2.9
LP T_2	53.5	53.2	64.9	51.3	48.5	54.3	-1.19	-2.16	25.4	5.0	2.2
HP T_2	58.0	60.4	50.8	54.5	52.9	55.4	-1.61	+0.38	25.8	2.5	3.0
M14 T_2	61.2	59.1	48.9	50.4	50.3	54.0	-3.05	+1.12	26.4	0.9	1.5
C103 T_2	43.8	51.6	50.2	35.1	40.7	44.3	-2.27	-1.29	27.5	11.3	5.2
M14 x C103 T_2	52.7	54.3	43.9	46.6	37.3	47.0	-3.85	-0.62	26.3	6.0	3.1
Mean	55.3	56.1	54.9	50.7	46.3	52.6	-2.34	-0.97	25.7	4.1	4.1

Table 17. Agronomic data of 4 composites from 61 selections out of M14 x C103 and 3 checks, in test-cross performance with two testers, T_1 and T_2, grown near Sheldon, Iowa, 1964

Groups of selections	Root lodging at rates (1000 plants/acre) 12	16	20	24	28	Mean	Stalk lodging at rates (1000 plants/acre) 12	16	20	24	28	Mean	% Dropped ears mean
LT T_1	0.0	0.0	0.0	0.0	0.0	0.0	5.1	10.0	7.7	17.6	12.6	10.6	10.7
HT T_1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	8.6	12.5	13.7	8.1	10.0
LP T_1	0.0	0.0	0.0	0.0	0.0	0.0	6.9	11.9	7.2	16.3	14.2	11.3	11.0
HP T_1	0.0	0.0	0.0	0.0	0.0	0.0	1.7	5.3	11.0	7.7	15.2	8.2	10.3
M14 T_1	0.0	0.0	0.0	0.0	0.0	0.0	1.7	8.3	11.0	14.1	15.4	10.1	7.8
C103 T_1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	9.6	2.8	3.8	3.7	14.2
M14 x C103 T_1	0.0	0.0	0.0	0.0	0.0	0.0	3.3	5.1	8.0	7.8	7.5	6.3	12.5
LT T_2	0.0	0.0	2.1	0.0	0.0	0.4	5.0	10.3	11.4	15.2	12.8	10.9	6.1
HT T_2	0.0	0.0	0.0	0.0	0.0	0.0	13.7	12.5	25.5	13.8	13.1	15.7	4.7
LP T_2	0.0	2.5	0.0	0.0	0.0	0.6	6.8	10.8	13.0	12.5	9.7	10.6	3.1
HP T_2	0.0	0.0	1.1	0.9	0.0	0.4	5.4	11.7	16.9	29.9	15.2	15.8	5.3
M14 T_2	0.0	0.0	6.9	1.9	0.0	1.7	10.2	16.0	11.0	22.6	9.8	13.9	6.3
C103 T_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	7.1	16.6	7.4	7.0	5.9
M14 x C103 T_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1	20.1	21.3	15.0	14.1	5.2
Mean	0.0	0.2	0.7	0.2	0.0	0.2	4.3	9.1	12.0	15.0	11.8	10.4	8.1

Table 18. Agronomic data of 4 composites from 61 selections out of M14 x C103, and 3 checks, in test-cross performance with two testers, T_1 and T_2, grown near Newell, Iowa, 1964, showing linear and quadratic yield regressions R_1 and R_q across population rates

Entry	Yield - cwt per acre at rates (1000 plants/acre) 12	16	20	24	28	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at 24	28
LT T_1	69.9	74.4	75.9	69.1	62.5	70.4	-2.01	-2.18	22.3	5.1	9.7
HT T_1	67.1	67.9	74.2	69.3	59.6	67.6	-1.36	-2.30	22.9	7.6	5.3
LP T_1	62.1	68.4	66.3	67.4	57.4	64.3	-1.04	-2.10	23.0	8.1	7.4
HP T_1	68.7	75.7	73.2	60.1	64.0	68.4	-2.50	-1.20	22.6	8.0	6.0
M14 T_1	57.1	72.0	64.9	66.5	60.7	64.2	+0.17	-2.34	23.0	0.9	0.7
C103 T_1	62.4	70.2	70.5	68.2	53.6	65.0	-1.96	-3.39	21.7	6.6	11.9
M14 x C103 T_1	67.6	71.4	79.2	64.4	62.9	69.1	-1.64	-2.37	22.2	3.6	7.7
LT T_2	64.9	72.9	69.2	64.4	58.1	65.9	-2.21	-2.12	23.0	7.8	8.1
HT T_2	64.4	70.1	69.9	60.4	58.9	64.7	-2.07	-1.69	24.9	8.8	7.2
LP T_2	63.2	69.0	61.8	58.2	55.5	61.6	-2.62	-0.95	22.7	5.3	4.3
HP T_2	67.0	70.8	67.9	61.4	63.7	66.2	-1.60	-0.47	23.0	6.4	3.0
M14 T_2	60.2	65.8	67.4	67.3	66.5	65.5	+1.41	-1.04	24.0	2.7	0.8
C103 T_2	63.5	61.0	63.5	47.8	50.6	57.3	-3.90	-0.54	24.0	11.3	6.1
M14 x C103 T_2	56.4	63.7	69.4	55.0	58.6	60.7	-0.43	-1.96	24.8	5.9	7.7
Mean	63.9	69.5	69.6	62.8	59.5	65.1	-1.55	-1.76	23.1	6.3	6.1

Table 19. Agronomic data of 4 composites from 61 selections out of M14 x C103 and 3 checks, in test-cross performance with two testers, T_1 and T_2, grown near Newell, Iowa, 1964

Entry	Root lodging at rates (1000 plants/acre) 12	16	20	24	28	Mean	Stalk lodging at rates (1000 plants/acre) 12	16	20	24	28	Mean	% Dropped ears mean
LT T_1	0.0	0.0	4.3	34.2	7.6	9.2	1.7	3.9	4.2	5.1	3.0	3.6	5.0
HT T_1	5.2	48.4	12.6	25.9	15.5	21.5	3.4	3.9	4.2	4.8	7.8	4.8	3.0
LP T_1	32.8	16.1	10.2	13.0	5.7	15.6	1.8	3.9	5.1	6.4	3.3	4.1	8.1
HP T_1	3.4	16.3	24.3	23.1	9.0	15.2	3.4	2.6	7.1	5.2	5.2	4.7	5.8
M14 T_1	20.6	29.2	26.1	22.5	18.8	23.4	1.7	2.6	6.5	7.6	6.7	5.0	2.9
C103 T_1	0.0	0.0	8.3	5.8	17.6	6.3	0.0	1.3	2.2	4.8	1.5	2.0	10.1
M14 x C103 T_1	0.0	5.6	16.0	14.8	1.5	7.6	0.0	3.9	3.0	9.0	10.0	5.2	7.4
LT T_2	11.7	20.0	8.1	12.1	4.7	11.3	5.0	7.5	7.3	12.2	9.2	8.2	1.7
HT T_2	20.0	12.9	11.5	23.8	44.4	22.5	3.3	5.2	12.3	6.2	6.4	6.7	3.0
LP T_2	8.3	7.7	35.5	29.3	23.4	20.8	6.7	12.8	2.1	8.7	8.7	7.8	3.8
HP T_2	10.0	19.3	15.6	7.4	14.9	13.4	1.7	4.0	3.1	23.6	9.6	8.4	2.1
M14 T_2	16.1	57.9	25.4	17.2	7.1	24.7	1.8	4.2	8.3	10.1	3.9	5.7	2.5
C103 T_2	21.7	6.4	11.1	15.6	8.3	12.6	0.0	3.8	8.2	7.8	4.6	4.9	2.4
M14 x C103 T_2	5.0	13.9	9.3	30.5	31.0	17.9	11.3	11.3	5.1	10.2	8.5	9.3	3.9
Mean	11.1	18.1	15.6	19.7	15.0	15.9	3.0	5.1	5.6	8.7	6.3	5.7	4.4

Table 20. Agronomic data of 4 composites from 61 selections out of M14 x C103, and 3 checks, in test-cross performance with two testers, T_1 and T_2, grown near Hampton, Iowa, 1964, showing linear and quadratic yield regressions, R_ℓ and R_q across population rates.

	Yield - cwt per acre at rates (1000 plants/acre)									% Barren stalks at	
Entry	12	16	20	24	28	Mean	R_ℓ	R_q	% H_2O	24	28
LT T_1	62.1	71.6	68.7	67.0	52.7	64.4	-2.34	-3.31	24.6	3.6	0.7
HT T_1	67.5	68.0	72.6	69.0	54.9	66.4	-2.42	-2.67	24.3	2.6	2.5
LP T_1	59.8	58.1	66.1	62.9	51.9	59.8	-1.10	-2.13	23.7	2.7	4.9
HP T_1	65.3	73.5	71.1	63.2	53.7	65.4	-3.35	-2.92	24.0	4.4	5.4
M14 T_1	49.1	66.1	66.0	61.3	51.0	58.7	-0.10	-4.23	23.1	3.4	3.2
C103 T_1	58.0	69.4	58.4	48.8	42.1	55.3	-5.24	-2.49	26.2	8.5	18.0
M14 x C103 T_1	66.3	66.3	70.5	67.2	45.4	63.1	-4.09	-3.65	24.3	1.7	7.6
LT T_2	59.5	67.6	52.3	61.0	46.8	57.5	-3.20	-1.47	25.0	0.8	4.4
HT T_2	55.0	60.4	70.2	61.9	45.9	58.7	-1.67	-4.35	26.3	4.5	3.4
LP T_2	59.7	60.9	62.9	51.6	42.1	55.4	-4.45	-2.48	25.2	3.7	5.3
HP T_2	54.3	66.3	65.0	55.5	48.5	57.9	-2.24	-3.30	25.8	5.4	3.1
M14 T_2	58.2	63.7	62.4	67.1	61.1	62.5	+0.92	-1.21	25.1	0.0	0.0
C103 T_2	54.1	52.5	34.5	39.8	29.3	42.1	-6.23	+0.39	28.2	8.1	8.9
M14 x C103 T_2	56.4	64.1	54.9	54.9	55.1	57.1	-1.18	-0.41	26.9	2.8	2.3
Mean	59.0	64.9	62.6	59.4	48.6	58.9	-2.62	-2.44	25.2	3.7	7.0

Table 21. Agronomic data of 4 composites from 61 selections out of M14 x C103, and 3 checks, in test-cross performance with two testers, T_1 and T_2, grown near Hampton, Iowa, 1964

Groups of selections	Root lodging at rates (1000 plants/acre) 12	16	20	24	28	Mean	Stalk lodging at rates (1000 plants/acre) 12	16	20	24	28	Mean	% Dropped ears mean
LT T_1	0.0	6.3	9.3	5.4	4.5	5.1	1.7	7.6	8.2	17.1	12.0	9.3	3.9
HT T_1	0.0	0.0	10.5	0.0	2.4	2.6	4.7	6.6	16.9	25.6	21.9	15.1	4.9
LP T_1	0.0	1.7	3.1	4.4	1.7	2.2	1.8	15.5	14.7	15.3	21.3	13.7	5.4
HP T_1	0.0	0.0	2.0	0.0	2.9	1.0	1.5	3.8	11.0	28.9	15.3	12.1	6.2
M14 T_1	3.7	11.5	13.3	10.9	17.1	11.3	9.1	11.4	4.3	8.5	12.2	9.1	3.4
C103 T_1	0.0	0.0	0.0	0.0	0.0	0.0	1.7	3.8	5.2	3.8	8.5	4.6	4.5
M14 x C103 T_1	0.0	0.0	10.5	0.8	5.8	3.4	1.7	6.3	6.3	14.6	13.2	8.4	4.4
LT T_2	0.0	0.0	16.4	7.1	9.7	6.6	1.7	12.4	21.8	24.2	20.0	16.0	1.5
HT T_2	0.0	11.3	7.0	10.7	9.7	7.7	0.0	13.6	34.6	22.0	24.2	18.9	0.2
LP T_2	0.0	1.3	7.7	2.8	3.1	3.0	3.4	10.5	22.3	30.6	26.7	18.7	0.9
HP T_2	10.3	7.5	10.0	1.8	8.4	7.6	1.7	7.6	17.0	20.2	24.9	14.3	2.4
M14 T_2	18.9	23.1	19.0	22.1	30.6	22.7	5.1	19.8	28.0	22.7	42.1	23.5	2.3
C103 T_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	3.3	8.8	13.8	5.9	1.4
M14 x C103 T_2	0.0	16.1	5.6	2.7	2.9	5.5	4.8	5.4	18.0	22.9	24.9	15.2	1.5
Mean	2.3	5.6	8.1	4.9	7.1	5.6	2.8	9.1	15.1	18.9	20.1	13.2	3.1

Table 22. Agronomic data of 4 composites from 61 selections out of M14 x C103, and 3 checks, in test-cross performance with two testers, T_1 and T_2, grown near Ames, Iowa, 1964, showing linear and quadratic yield regressions, R_ℓ and R_q across population rates

Entry	Yield - cwt per acre at rates (1000 plants/acre) 12	16	20	24	28	Mean	R_ℓ	R	% H_2O	% Barren stalks at 24	28
LT T_1	56.6	62.7	59.0	52.7	41.9	54.6	-3.94	-2.60	23.7	19.3	11.8
HT T_1	57.0	64.1	53.7	46.2	50.6	54.3	-3.07	-0.18	24.5	22.5	13.7
LP T_1	60.9	54.1	55.7	41.1	44.7	51.3	-4.54	+0.33	24.0	14.8	22.3
HP T_1	58.2	55.1	50.5	45.9	43.2	50.6	-3.92	+0.06	23.8	21.1	15.5
M14 T_1	52.4	55.9	42.4	40.0	47.1	47.6	-2.65	+1.31	22.0	18.4	13.9
C103 T_1	53.9	44.9	50.5	41.7	35.1	45.2	-4.08	-0.69	25.9	25.6	33.6
M14 x C103 T_1	56.5	53.0	48.4	39.2	30.7	45.6	-6.54	-1.04	24.0	15.3	23.2
LT T_2	54.0	52.8	58.4	51.4	47.8	52.9	-1.38	-1.24	24.5	11.4	14.6
HT T_2	56.5	56.4	59.8	52.2	49.3	54.9	-1.86	-1.19	24.9	9.6	9.5
LP T_2	57.4	59.6	54.7	44.0	39.3	51.0	-5.18	-1.40	24.9	15.8	16.5
HP T_2	53.4	58.9	56.6	51.1	48.8	53.8	-1.70	-1.34	24.5	11.1	11.5
M14 T_2	49.9	49.2	55.4	50.2	51.4	51.2	+0.40	-0.54	23.2	4.7	5.1
C103 T_2	50.4	46.7	49.2	39.0	31.1	43.3	-4.63	-1.51	26.5	17.9	30.6
M14 x C103 T_2	51.9	57.9	51.0	46.0	49.1	51.2	-1.75	-0.28	25.0	13.5	10.5
Mean	54.9	55.1	53.3	45.8	43.6	50.5	-3.20	-0.74	24.4	15.8	16.6

Table 23. Agronomic data of 4 composites from 61 selections out of M14 x C103, and 3 checks, in test-cross performance with two testers, T_1 and T_2, grown near Ames, Iowa, 1964

Groups of selections	Root lodging at rates (1000 plants/acre) 12	16	20	24	28	Mean	Stalk lodging at rates (1000 plants/acre) 12	16	20	24	28	Mean	% Dropped ears mean
LT T_1	5.1	4.1	0.0	14.9	16.2	8.1	3.6	7.9	8.5	7.0	10.4	7.5	4.8
HT T_1	5.0	21.2	20.4	9.4	11.3	13.5	8.3	1.3	5.3	10.0	4.0	5.8	2.8
LP T_1	3.4	5.1	16.3	4.5	7.6	7.4	3.4	5.3	1.0	4.3	5.9	4.0	4.2
HP T_1	11.1	15.0	19.6	13.6	20.2	15.9	6.9	7.5	8.2	5.1	5.4	6.6	5.3
M14 T_1	17.1	37.1	26.0	12.2	17.0	21.9	6.9	5.7	13.5	3.5	10.8	8.1	1.4
C103 T_1	0.0	0.0	4.1	0.9	2.9	1.6	0.0	3.7	3.0	2.5	4.4	2.7	10.1
M14 x C103 T_1	1.7	17.6	10.2	14.4	4.8	9.7	3.4	6.6	3.1	3.6	5.7	4.5	4.9
LT T_2	6.8	2.5	17.3	13.0	14.5	10.8	3.4	7.6	9.3	8.7	6.6	7.1	3.5
HT T_2	8.3	17.6	15.2	14.8	13.2	13.8	5.0	5.1	13.1	14.3	15.4	10.6	0.8
LP T_2	8.3	11.4	17.2	17.4	20.5	15.0	5.0	6.4	12.2	7.9	7.1	7.7	2.7
HP T_2	17.3	5.0	15.5	17.2	15.1	14.0	16.1	21.6	12.5	17.1	15.0	16.5	5.5
M14 T_2	33.6	32.0	25.2	38.2	33.5	32.5	11.9	16.0	13.3	13.1	12.5	13.4	1.3
C103 T_2	3.4	0.0	6.1	5.1	7.6	4.4	1.7	3.9	7.1	8.5	6.0	5.4	2.3
M14 x C103 T_2	16.1	9.5	17.5	18.0	4.0	13.0	10.5	16.5	13.1	6.3	12.2	11.7	2.0
Mean	9.8	12.7	15.0	13.8	13.4	12.9	6.2	8.2	8.8	8.0	8.7	8.0	3.7

Table 24. Agronomic data of 4 composites from 61 selections out of M14 x C103, and 3 checks, in test-cross performance with two testers, T_1 and T_2, grown near Ankeny, Iowa, 1964, showing linear and quadratic yield regressions, R_ℓ and R_q across population rates

Entry	Yield - cwt per acre at rates (1000 plants/acre) 12	16	20	24	28	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at 24	28
LT T_1	51.0	49.3	61.9	49.1	41.5	50.6	-1.92	-2.65	20.6	5.1	14.6
HT T_1	59.7	54.5	46.6	44.1	42.4	49.5	-4.50	+0.89	20.4	11.1	6.8
LP T_1	56.8	57.0	51.4	34.8	32.7	46.6	-7.04	-1.11	20.4	11.4	9.7
HP T_1	50.0	61.2	63.4	41.6	38.8	51.0	-4.20	-3.71	20.5	5.8	15.0
M14 T_1	48.2	57.8	46.8	43.1	45.4	48.3	-2.03	-0.52	18.8	12.2	7.9
C103 T_1	60.6	54.3	53.2	33.5	31.2	46.6	-7.96	-0.75	21.2	11.2	18.9
M14 x C103 T_1	48.9	46.2	51.7	38.6	30.0	43.1	-4.54	-2.17	20.3	8.5	21.8
LT T_2	49.4	58.3	42.0	38.3	38.0	45.2	-4.28	-0.41	21.7	8.7	17.7
HT T_2	50.1	50.2	51.7	39.4	39.5	46.2	-3.20	-0.98	21.7	5.8	8.3
LP T_2	42.1	47.0	45.2	36.6	38.8	42.0	-1.70	-0.87	20.8	12.2	22.7
HP T_2	56.6	52.0	59.2	44.3	37.6	50.0	-4.57	-1.88	21.0	6.8	12.3
M14 T_2	49.4	54.9	53.3	45.3	45.5	49.7	-1.74	-1.21	20.9	7.7	3.9
C103 T_2	45.2	42.0	41.9	32.9	29.2	38.2	-4.11	-0.71	22.4	20.3	14.4
M14 x C103 T_2	54.3	57.2	55.9	45.3	38.7	50.3	-4.31	-2.02	20.9	4.3	13.5
Mean	51.6	53.0	51.7	40.5	37.8	46.9	-4.00	-1.29	20.8	9.4	13.4

Table 25. Agronomic data of 4 composites from 61 selections out of M14 x C103, and 3 checks, in test-cross performance with two testers, T_1 and T_2, grown near Ankeny, Iowa, 1964

Groups of selections	Root lodging at rates (1000 plants/acre)						Stalk lodging at rates (1000 plants/acre)						% Dropped ears
	12	16	20	24	28	Mean	12	16	20	24	28	Mean	mean
LT T_1	0.0	0.0	1.0	4.2	3.8	1.8	1.7	5.1	7.0	7.8	11.3	6.6	2.9
HT T_1	8.3	0.0	1.0	6.8	6.9	4.6	0.0	6.4	4.4	6.0	5.7	4.5	5.4
LP T_1	0.0	0.0	4.0	1.7	7.4	2.6	0.0	5.0	12.3	10.6	6.8	6.9	5.7
HP T_1	0.0	0.0	1.1	5.9	1.6	1.7	1.7	7.7	11.5	4.0	10.1	7.0	3.9
M14 T_1	0.0	8.6	0.0	12.0	14.7	7.1	3.4	8.7	3.2	8.7	10.5	6.9	1.6
C103 T_1	0.0	0.0	1.0	3.5	1.7	1.2	3.4	2.5	1.0	6.0	6.6	3.9	7.4
M14 x C103 T_1	0.0	0.0	0.0	12.0	7.4	3.9	5.4	4.0	5.0	3.4	5.2	4.6	1.9
LT T_2	0.0	2.5	3.0	20.9	19.6	9.2	6.7	5.0	10.3	12.8	9.9	8.9	4.3
HT T_2	6.8	1.3	5.0	27.6	27.9	13.7	8.5	1.4	18.0	8.3	5.3	8.3	2.1
LP T_2	6.8	5.1	3.1	0.9	8.4	4.9	6.9	6.3	9.2	11.3	10.2	8.8	3.5
HP T_2	0.0	0.0	6.5	4.2	36.5	9.4	11.7	13.0	9.6	11.1	9.5	11.0	2.7
M14 T_2	22.1	11.5	5.3	49.4	41.3	25.9	3.3	15.6	22.2	28.2	17.0	17.3	3.1
C103 T_2	0.0	0.0	2.0	6.2	4.5	2.5	0.0	2.6	11.0	5.3	17.5	7.3	3.6
M14 x C103 T_2	6.9	3.8	7.2	4.4	10.8	6.6	5.1	3.9	10.5	13.8	9.5	8.6	1.6
Mean	3.6	2.3	2.9	11.4	13.7	6.8	4.1	6.2	9.7	9.8	9.7	7.9	3.6

Table 26. Analyses of variance for grain yields in cwt per acre obtained in experiments 74-78 grown near Sheldon, Newell, Hampton, Ames, and Ankeny, respectively, showing the orthogonal subdivision of the entry and rates components and the interaction of entries x rates

Source	d.f.	Sheldon	Newell	Mean squares Hampton	Ames	Ankeny
Reps	1	23.21	32.35	100.47	834.48*	430.85*
Rates (R)	4	476.20*	542.01*	1087.62**	830.49*	1442.78**
Linear (R_ℓ)	1	1527.09**	674.87*	1917.84**	2874.89**	4495.21**
Quadratic (R_q)	1	366.24	1217.01**	2349.06**	212.47	657.55**
Cubic	1	7.66	225.72	1.37	149.94	351.68*
Quartic	1	3.84	50.43	82.21	84.64	266.70*
Reps x rates	4	42.96	59.32	18.65	85.97	30.47
Crosses	13	126.14**	52.12*	365.60**	139.26**	142.42
Testers	1	86.74	529.62**	1263.60**	58.37	140.40
Entries	6	242.90**	118.01*	450.29**	250.12**	154.00
LT vs HT	1	12.54	38.03	25.92	7.23	0.02
LP vs HP	1	7.23	187.06**	163.62*	10.61	393.13**
T vs P	1	7.08	84.26	90.10	124.50*	4.61
Selections vs checks	1	818.45**	214.93**	609.25**	1062.76**	85.68
M14 vs C103	1	585.23**	136.90*	1416.10**	263.17**	432.96**
M14 + C103 vs (M14xC103)	1	26.89	46.88	396.76**	32.97	13.20
Entries x testers	6	15.94	55.87*	131.24*	41.89	131.18**
LT vs HT	1	1.60	6.08	1.37	12.77	10.71
LP vs HP	1	0.32	0.93	24.49	29.93	31.86
T vs P	1	0.80	7.27	10.35	20.60	11.25
Selections vs checks	1	43.40	30.15	17.88	35.04	115.34
M14 vs C103	1	42.03	198.92**	727.61**	78.40	239.12
M14 + C103 vs (M14xC103)	1	7.50	90.48	5.63	74.58	378.79**

Table 26 (Continued)

Source	d.f.	Sheldon	Newell	Mean squares Hampton	Ames	Ankeny
Testers x rates	4	26.15	38.64	49.58	73.33	31.02
Entries x rates	24	41.00	33.70	66.94	34.50	40.08
Entries x R_{ℓ}	6	32.04	55.43	128.55*	68.72	65.89
LT vs HT	1	40.47	3.50	10.59	0.82	11.55
LP vs HP	1	6.55	0.97	0.00	84.26	0.00
T vs P	1	0.04	0.03	5.89	66.05	32.67
Selections vs checks	1	50.62	50.17	0.22	0.00	2.38
M14 vs C103	1	39.34	277.89**	754.61**	208.01**	343.21**
M14+C103 vs (M14xC103)	1	55.23	0.03	0.01	53.20	5.55
Entries x R_q	6	47.75	11.78	35.53	26.81	47.50
LT vs HT	1	152.52**	0.65	35.10	43.88	61.51
LP vs HP	1	74.75	13.30	17.92	0.38	91.26
T vs P	1	10.54	45.27	3.63	28.71	67.87
Selections vs checks	1	6.35	9.62	77.32	23.49	1.30
M14 vs C103	1	9.32	1.98	78.39	60.91	0.56
M14+C103 vs (M14xC103)	1	33.00	0.00	0.79	3.48	62.49
Remainder	12	42.10	33.79	51.85	22.16	23.46
Rates x testers x_{entries}	24	30.34	16.96	39.39	29.36	47.58
Error	65	23.18	23.30	33.27	19.29	40.01
Total	139					

Table 27. Analysis of variance of grain moisture percentage at harvest for 8 composites and 6 checks grown at Ames, Ankeny, Hampton, Newell and Sheldon Iowa in 1964

		Mean squares				
Source	d.f.	Ames	Ankeny	Hampton	Newell	Sheldon
Replications	1	7.36	3.09	24.19	0.00	0.74
Rates	4	14.12*	0.14	12.50**	17.80**	3.36*
Rates linear	1	15.00	0.29	14.49**	59.99**	12.90*
Rates quadratic	1	37.72*	0.23	11.76**	9.49*	0.00
Rates remainder	2	1.88	0.02	11.88**	0.85	0.26
Error (a)	4	2.06	0.56	0.26	0.49	1.68
Crosses	13	12.26**	6.95**	19.10**	8.97**	8.36**
Testers	1	22.64**	36.61**	108.42**	53.44**	41.26**
Entries	6	22.43**	7.25**	21.09**	4.25**	9.59**
LT vs HT	1	4.49	0.12	2.45	14.76**	6.72*
LP vs HP	1	0.93	0.19	1.93	0.02	0.00
T vs P	1	0.27	2.93	2.70	3.96	16.02**
Selections vs checks	1	0.24	0.51	22.01**	1.37	10.21*
M14 vs C103	1	128.52**	39.01	97.34**	4.03	21.17**
M14 + C103 vs (M14 x C103)	1	0.10	0.78	0.07	1.39	3.43
Entries x testers	6	0.36	1.72	2.24	6.27**	1.64
LT vs HT x testers	1	0.36	0.12	6.32	4.56*	0.12
LP vs HP x testers	1	0.21	0.07	0.16	1.26	0.01
T vs P x testers	1	0.21	2.85	1.22	9.38**	2.45
Selections vs checks x testers	1	0.58	2.06	4.70	14.94**	3.55
M14 vs C103 x testers	1	0.70	1.89	0.00	4.29*	0.81
M14 + C103 vs (M14xC103) x testers	1	0.14	3.30	1.01	3.16	2.52
Testers x rates	4	0.63	0.63	0.83	0.93	1.53

Table 27 (Continued)

Source	d.f.	Ames	Ankeny	Hampton	Newell	Sheldon
Entries x rates	24	1.08	1.05	1.55	1.93	1.10
Entries x rates linear	6	1.35	0.71	1.93	2.50	0.54
LT vs HT x rates linear	1	0.21	3.36	2.52	0.51	0.00
LP vs HP x rates linear	1	2.48	0.31	3.40	9.18**	0.17
T vs P x rates linear	1	3.14	0.19	2.89	3.45	0.15
Selections vs checks x rates linear	1	1.97	0.20	0.54	0.39	0.00
M14 vs C103 x rates linear	1	0.10	0.20	0.90	1.22	0.29
M14 + C103 vs (M14 x C103) rates linear	1	0.23	0.01	1.36	0.26	2.60
Entries x rates quadratic	6	1.05	1.39	1.35	1.75	1.38
LT vs HT x rates quadratic	1	1.22	1.62	2.58	0.89	0.04
LP vs HP x rates quadratic	1	0.05	2.15	2.20	1.39	0.06
T vs P x rates quadratic	1	0.09	1.02	1.49	2.42	1.37
Selections vs checks x rates quadratic	1	1.73	1.76	0.21	1.49	6.37*
M14 vs C103 x rates quadratic	1	1.96	1.61	1.26	4.05*	0.44
M14 + C103 vs (M14 x C103) x rates quadratic	1	1.26	0.20	0.33	0.26	0.04
Entries x rates remainder	12	0.97	1.06	1.45	1.74	1.04
Rates x testers x entries	24	0.68	1.53	1.26	1.13	1.89
Error (b)	65	1.44	0.92	1.69	1.03	1.51
Coefficient of variation		4.92%	4.61%	5.16%	4.40%	4.78%

Table 28. Analysis of variance for grain moisture per cent at harvest for data combined over five locations

Source	d.f.	SS	MS	F
Locations (L)	4	2122.97	530.74	74.96**
Reps/L	5	35.39	7.08	
Rates (R)	4	35.10	8.77	0.90
Linear (R_l)	1	28.51	28.51	2.91
Quadratic (R_q)	1	5.52	5.52	0.61
Cubic	1	0.21	0.21	0.02
Quartic	1	0.86	0.86	0.09
L x R	16	156.57	9.79	9.69**
Error b	20	20.20	1.01	
Testers (T)	1	244.38	244.38	54.30**
L x T	4	17.99	4.50	3.41**
T x R	4	4.70	1.17	1.37
T x R x L	16	13.54	0.85	0.64
Entries (E)	6	235.24	39.21	6.17**
LT vs HT	1	19.10	19.10	3.00
LP vs HP	1	0.11	0.11	1.73
T vs P	1	19.50	19.50	3.07
Selections vs checks	1	15.61	15.61	2.46
M14 vs C103	1	180.50	180.50	28.42**
M14 and C103 vs (M14xC103)	1	0.44	0.44	0.07
Entries x locations	24	152.49	6.35	4.81**
LT vs HT	4	9.45	2.36	1.79
LP vs HP	4	2.97	0.74	0.56
T vs P	4	6.39	1.60	1.21
Selections vs checks	4	18.73	4.68	3.54**
M14 vs C103	4	109.57	27.39	20.75**
M14 and C103 vs (M14xC103)	4	5.34	1.33	1.00
Entries x rates	24	33.53	1.40	1.13
Entries x R_l	6	3.77	0.63	0.51
LT vs HT x R_l	1	1.44	1.44	1.17
LP vs HP x R_l	1	0.06	0.06	0.05
T vs P x R_l	1	0.60	0.60	0.49
Selections vs checks x R_l	1	0.13	0.13	0.10
M14 vs C103 x R_l	1	1.27	1.27	1.03
M14 and C103 vs (M14xC103) x R_l	1	0.27	0.27	0.22
Entries x R_q	6	14.41	2.40	1.95
LT vs HT x R_q	1	0.83	0.83	0.67
LP vs HP x R_q	1	5.84	5.84	4.75*
T vs P x R_q	1	0.94	0.94	0.76
Selections vs checks x R_q	1	1.45	1.45	1.17

Table 28 (Continued)

Source	d.f.	SS	MS	F
M14 vs C103 x R_q	1	5.28	5.28	4.29*
M14 and C103 vs (M14xC103) x R_q	1	0.06	0.06	0.05
Entries x rates - Remainder	12	15.35	1.28	1.04
E x L x R	96	118.23	1.23	0.93
E x L x R_l	24	38.47	1.60	1.21
LT vs HT	4	5.16	1.29	0.98
LP vs HP	4	15.49	3.87	2.93*
T vs P	4	9.22	2.30	1.74
Selections vs checks	4	2.98	0.74	0.56
M14 vs C103	4	1.43	1.11	0.84
M14 and C103 vs (M14xC103)	4	4.19	1.05	0.80
E x L x R_q	24	27.13	1.13	0.86
LT vs HT	4	5.51	1.37	1.03
LP vs HP	4	0.01	0.00	0.00
T vs P	4	5.45	1.36	1.03
Selections vs checks	4	10.11	2.53	1.92
M14 vs C103	4	4.02	1.00	0.75
M14 and C103 vs (M14xC103)	4	2.03	0.51	0.39
E x L x R - remainder	48	52.63	1.10	0.83
E x T	6	29.06	4.84	2.62**
LT vs HT	1	6.62	6.62	3.58
LP vs HP	1	1.08	1.08	0.77
T vs P	1	0.27	0.27	0.20
Selections vs checks	1	20.73	20.73	11.20**
M14 x C103	1	0.22	0.22	0.20
M14 and C103 vs (M14xC103)	1	0.20	0.20	0.10
E x T x L	24	44.34	1.85	1.40
E x T x R	24	37.37	1.56	1.26
E x T x R x L	96	118.23	1.23	0.93
Error c	325	429.64	1.32	
Total	699			

Table 29. Agronomic data of 4 composites from 61 selections out of M14 x C103, and 3 checks, in test-cross performance with two testers, T_1 and T_2 at 5 random Iowa locations, showing linear and quadratic yield regressions, R_ℓ and R_q across population rates

	Yield - cwt per acre at rates (1000 plants/acre)									% Barren stalks at	
Entry	12	16	20	24	28	Mean	R_ℓ	R_q	% H_2O	24	28
LT T_1	59.2	63.7	64.3	58.4	48.5	58.8	-2.67	-2.52	23.3	7.0	8.4
HT T_1	62.8	61.8	60.6	57.0	51.2	58.7	-2.80	- .86	23.6	9.6	6.9
LP T_1	59.1	59.1	60.1	52.0	46.7	55.4	-3.19	-1.41	23.1	8.1	9.9
HP T_1	60.2	64.7	64.3	52.0	49.7	58.2	-3.38	-1.81	23.0	8.2	8.7
M14 T_1	51.8	61.7	54.9	54.1	50.7	54.6	-0.98	-1.47	22.3	7.0	5.8
C103 T_1	57.9	58.8	56.4	47.0	40.8	52.2	-4.60	-1.51	24.3	12.2	15.8
M14 x C103 T_1	58.6	58.7	61.6	51.1	41.8	54.4	-4.12	-2.29	23.1	6.7	13.3
LT T_2	56.5	61.4	56.3	54.0	47.0	55.4	-2.64	-1.50	23.9	6.9	9.9
HT T_2	56.4	58.0	60.8	54.1	49.7	55.8	-1.73	-1.53	24.9	6.1	6.3
LP T_2	55.2	58.0	57.9	48.4	44.9	52.9	-3.00	-1.58	23.8	8.4	10.2
HP T_2	57.9	61.7	59.9	53.4	50.3	56.6	-2.35	-1.32	24.0	6.4	6.6
M14 T_2	55.8	58.6	57.5	56.1	55.0	56.6	-0.41	-0.57	23.9	3.0	2.3
C103 T_2	51.4	50.8	47.9	38.9	36.2	45.1	-4.23	-0.73	25.7	13.8	13.0
M14 x C103 T_2	54.3	59.4	55.0	49.6	47.8	53.3	-2.30	-1.04	24.8	6.5	7.4
Mean	56.9	59.7	58.4	51.9	47.2	54.8	-2.74	-1.44	23.9	7.8	8.9

Table 30. Agronomic data of 4 composites from 61 selections out of M14 x C103, and 3 checks, in test-cross performance with two testers, T_1 and T_2, at 5 random Iowa locations in 1964

Groups of selections	Root lodging at rates (1000 plants/acre) 12	16	20	24	28	Mean	Stalk lodging at rates (1000 plants/acre) 12	16	20	24	28	Mean	% Dropped ears mean
LT T_1	1.0	2.1	2.9	11.7	6.4	4.8	2.7	6.9	7.1	10.9	9.9	7.5	5.5
HT T_1	3.7	13.9	8.9	8.4	7.2	8.4	3.3	4.7	7.9	22.7	10.6	9.8	5.2
LP T_1	7.2	4.6	6.7	4.7	4.5	5.5	2.8	8.3	8.1	10.6	10.3	8.0	6.9
HP T_1	2.9	6.3	9.4	8.5	6.7	6.8	3.0	2.3	9.8	10.2	10.2	7.1	6.3
M14 T_1	8.3	17.3	13.1	11.5	13.3	12.7	4.6	7.3	7.7	8.5	11.1	7.8	3.4
C103 T_1	0.0	0.0	2.7	2.0	2.2	1.4	1.0	2.8	4.2	4.0	5.0	3.4	9.3
M14 x C103 T_1	0.3	4.6	7.3	8.4	4.6	5.0	2.8	5.2	5.1	7.7	8.3	5.8	6.2
LT T_2	3.7	5.0	9.4	10.6	9.7	7.7	4.4	8.6	12.0	14.6	11.7	10.3	3.4
HT T_2	7.0	8.6	7.7	15.4	19.0	11.5	6.1	7.6	20.7	12.9	12.9	12.0	2.1
LP T_2	4.7	5.6	12.7	10.1	11.1	8.8	5.8	9.4	11.8	14.2	12.5	10.7	2.8
HP T_2	7.5	6.4	9.7	6.3	15.0	9.0	7.3	11.6	11.8	20.4	14.8	13.2	3.6
M14 T_2	18.1	24.9	16.4	25.8	24.8	22.0	6.5	14.3	16.6	19.3	17.1	14.8	3.1
C103 T_2	5.0	1.3	4.8	5.4	4.9	4.3	0.3	3.6	7.3	9.4	9.9	6.1	3.1
M14 x C103 T_2	5.6	8.7	7.9	11.1	9.7	8.6	6.3	10.2	13.4	14.9	14.0	11.8	2.9
Mean	5.3	7.8	8.5	10.0	9.9	8.3	4.1	7.3	10.2	12.9	11.3	9.2	6.4

Table 31. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 61 selections from M14 x C103 tested at 3 population levels in experiment 79 near Hampton, Iowa, 1964, with linear and quadratic yield regressions, R_ℓ and R_q, across population rates

Entry	1961 Nursery row number of selections	Yield-cwt/acre at rates (1000 plants per acre) 12	18	24	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at rate 24000
1	2205-11	65.1	74.3	69.2	69.5	+2.05	-2.38	23.0	3.8
2	2213-62	62.9	75.8	73.8	70.8	+5.45	-2.48	20.9	1.8
3	2223-44	62.2	62.1	79.1	67.8	+8.45	+2.85	25.9	0.0
$\bar{x}$ Elite		63.4	70.7	74.0	69.4	+5.30	-0.67	23.3	1.9
4	2207-55	51.0	64.8	59.3	58.4	+4.15	-3.22	27.8	0.9
5	2208-57	62.4	58.3	57.0	59.2	-2.70	+0.47	24.1	8.6
6	2209-13	62.2	69.6	61.6	64.5	-0.30	-2.57	22.8	0.9
7	2211-105	57.0	71.3	62.1	63.5	+2.55	-3.92	22.6	1.0
8	2212-92	55.4	61.5	66.0	61.0	+5.30	-0.27	22.2	0.8
9	2214-64	49.4	63.9	45.2	52.8	-2.10	-5.53	22.8	6.4
10	2217-66	60.1	69.2	61.1	63.5	+0.50	-2.87	26.1	8.3
11	2218-67	62.0	75.9	61.1	66.3	-0.45	-4.78	22.1	3.5
12	2219-95	55.0	60.8	57.2	57.7	+1.10	-1.57	25.5	3.7
13	2224-74	63.1	66.5	57.7	62.4	-2.70	-2.03	23.9	0.0
14	2225-21	64.3	58.9	60.0	61.1	-2.15	+1.08	23.9	0.0
15	2227-78	63.4	68.1	68.8	66.8	+2.70	-0.67	23.9	0.0
16	2230-117	63.5	65.6	53.0	60.7	-5.25	-2.45	22.2	1.9
$\bar{x}$ LT		59.1	65.8	59.2	61.4	+0.05	-2.22	23.8	2.8
17	2212-60	63.9	63.1	64.3	63.8	+0.20	+0.33	23.1	0.9
18	2227-49	59.7	68.6	68.0	65.4	+4.15	-1.58	24.1	2.6
19	2234-152	68.0	69.0	57.0	64.7	-5.50	-2.17	23.5	3.1
20	2235-153	53.2	62.0	57.6	57.6	+2.20	-2.20	24.7	4.7

Table 31 (Continued)

Entry	1961 Nursery row number of selections	Yield-cwt/acre at rates (1000 plants per acre) 12	18	24	Mean	R_{ℓ}	R_q	% H_2O	% Barren stalks at rate 24000
21	2236-195	59.2	60.2	63.1	60.8	+1.95	+0.32	24.2	0.9
22	2237-170	56.4	71.6	65.6	64.5	+4.60	-3.53	22.7	1.9
23	2238-196	66.4	79.5	73.6	73.2	+3.60	-3.17	23.5	3.0
24	2239-183	61.1	68.1	59.1	62.8	-1.00	-2.67	28.3	1.8
25	2244-129	62.2	51.6	52.3	55.4	-4.95	+1.88	23.4	7.1
26	2246-127	62.9	65.7	62.9	63.8	0.00	-0.93	24.2	1.1
27	2247-201	62.6	76.9	76.2	71.9	+6.80	-2.50	24.6	1.7
28	2250-193	63.7	76.1	64.1	68.0	+0.20	-4.06	24.5	2.9
29	2252-164	58.5	71.6	75.2	68.4	+8.35	-1.58	27.2	2.6
$\bar{x}$ HT		61.4	68.0	64.5	64.6	+1.55	-1.68	24.5	2.6
30	1968	60.5	69.1	70.2	66.6	+4.85	-1.25	25.3	0.0
31	1980	58.3	66.2	60.4	61.6	+1.05	-2.28	20.5	2.6
32	1985	56.0	52.5	52.6	53.7	-1.70	+0.60	20.2	3.5
33	1987	60.2	65.6	57.2	61.0	-1.50	-2.30	23.5	4.4
34	1992	57.2	54.8	52.9	55.0	-2.15	+0.08	24.9	10.4
35	1996	51.2	37.4	33.3	40.6	-8.95	+1.61	23.5	8.5
36	2003	60.3	64.4	66.3	63.7	+3.00	-0.37	22.5	4.4
37	2004	53.9	48.2	53.9	52.0	0.00	+1.90	21.3	7.1
38	2006	60.6	63.7	59.3	61.2	-0.65	-1.25	27.3	2.7
39	2013	62.0	67.8	61.5	63.8	-0.25	-2.02	21.4	0.9
40	2014	61.8	69.7	66.5	66.0	+2.35	-1.85	26.3	3.8
41	2017	55.6	61.9	55.5	57.7	-0.05	-2.12	25.0	8.8
42	2019	65.5	62.0	64.8	64.1	-0.35	+1.05	22.1	0.8
43	2021	59.1	78.4	73.1	70.2	+7.00	-4.10	22.3	2.7
44	2033	69.0	71.5	59.4	66.6	-4.80	-2.43	23.0	4.3

Table 31 (Continued)

Entry	1961 Nursery row number of selections	Yield-cwt/acre at rates (1000 plants per acre) 12	18	24	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at rate 24000
45	2034	61.4	72.1	59.5	64.3	-0.95	-3.88	23.5	2.6
$\bar{x}$ LP		59.5	62.8	59.1	60.5	-0.20	-1.17	23.3	4.2
46	2040	65.5	67.8	54.4	62.6	-5.55	-2.62	20.5	0.8
47	2044	55.4	58.0	54.3	55.9	-0.55	-1.05	22.4	0.9
48	2047	62.9	64.0	70.7	65.8	+3.90	+0.93	18.6	0.0
49	2052	62.5	71.1	63.3	65.6	+0.40	-2.73	23.8	6.8
50	2062	59.8	65.9	63.2	63.0	+1.70	-1.47	26.7	9.6
51	2064	55.6	66.1	46.9	56.2	-4.35	-4.95	24.2	12.8
52	2066	64.4	70.2	59.8	64.8	-2.30	-2.70	21.2	6.7
53	2067	67.5	71.9	56.3	65.2	-5.60	-3.33	23.9	3.4
54	2070	57.7	66.5	67.4	63.9	+4.85	-1.32	20.7	0.9
55	2074	62.3	71.1	55.1	62.8	-3.60	-4.13	22.7	4.5
56	2080	64.3	64.7	62.2	63.7	-1.05	-0.48	25.8	6.2
57	2083	67.8	67.8	65.2	66.9	-1.30	-0.43	23.7	1.7
58	2088	66.3	79.7	76.9	74.3	+5.30	-2.70	24.4	1.7
59	2094	65.0	75.3	58.3	66.2	-3.35	-4.55	23.9	0.9
60	2100	58.6	67.1	51.6	59.1	-3.50	-4.00	23.2	3.9
61	2104	62.6	56.5	62.4	60.5	-0.10	+2.00	21.4	8.0
$\bar{x}$ HP		62.4	67.7	60.5	63.5	-0.95	-2.08	22.9	4.3
M14		54.0	57.6	62.0	57.9	+4.00	+0.13	23.8	2.8
C103		52.3	52.9	51.5	52.2	-0.40	-0.33	25.0	10.3
M14 x C103		62.6	61.3	52.4	58.8	-5.10	-1.26	24.4	3.5
$\bar{x}$ checks		56.3	57.3	55.3	56.3	-0.50	-0.50	24.4	5.5
Grand $\bar{x}$		60.6	65.8	61.1	62.5	+0.25	-1.65	23.6	4.1

Table 32. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 61 selections from M14 x C103 tested at 3 population levels in experiment 79 near Hampton, Iowa, 1964

Entry	% Root lodging at rates (1000 plants per acre) 12	18	24	Mean	% Stalk lodging at rates (1000 plants per acre) 12	18	24	Mean	% Dropped ears mean
1	0.0	13.6	11.6	8.4	4.5	11.1	17.7	11.1	1.2
2	0.0	18.2	4.6	7.6	4.4	11.8	33.1	16.4	2.5
3	0.0	0.0	2.2	0.7	1.2	4.9	10.2	5.4	3.1
$\bar{x}$ Elite	0.0	10.6	6.1	5.6	3.4	9.3	20.3	11.0	2.3
4	0.0	0.5	3.1	1.2	0.3	11.5	13.1	8.3	5.1
5	0.2	0.0	1.0	0.4	3.1	9.2	26.0	12.8	12.5
6	0.1	5.2	0.0	1.8	0.3	9.3	15.6	8.4	2.9
7	0.0	0.5	4.5	1.7	3.6	3.7	16.4	7.9	7.8
8	0.1	3.2	2.0	1.8	7.0	9.9	28.7	15.2	1.9
9	0.0	4.3	0.4	1.6	0.5	6.0	10.0	5.5	2.9
10	0.0	9.6	15.1	8.2	1.8	6.8	15.4	8.0	5.1
11	0.0	0.7	2.2	1.0	3.3	15.8	32.6	17.2	6.3
12	0.0	0.7	0.2	0.3	5.2	5.9	23.9	11.7	2.2
13	0.0	14.3	11.1	8.5	2.3	13.5	32.1	16.0	2.2
14	0.1	2.6	7.2	3.3	0.5	6.7	11.2	6.1	3.9
15	0.0	0.0	1.0	0.3	0.0	18.2	14.0	10.7	2.8
16	0.3	0.0	0.0	0.1	3.5	3.3	10.7	5.8	1.6
$\bar{x}$ LT	0.1	3.2	3.7	2.3	2.4	9.2	19.2	10.3	4.4
17	0.0	3.1	1.0	1.4	1.2	1.1	18.8	7.0	2.3
18	0.0	0.0	2.8	0.9	0.5	13.0	34.5	16.0	2.9
19	0.0	1.1	0.0	0.4	4.1	15.1	11.3	10.2	1.2
20	6.3	7.8	0.3	4.8	0.3	5.7	0.0	2.0	3.9
21	0.0	0.0	0.4	0.1	0.0	2.3	17.8	6.7	6.0
22	0.1	9.9	5.7	5.2	1.3	14.8	30.0	15.4	4.0
23	0.0	6.0	7.3	4.4	2.8	10.1	14.8	9.2	12.1
24	0.1	1.5	4.8	2.1	0.0	3.3	15.6	6.3	2.3
25	0.0	2.2	0.5	0.9	1.1	4.5	24.3	10.0	3.7
26	0.0	3.1	1.0	1.4	8.7	19.8	28.3	18.9	1.9
27	1.7	2.8	4.1	2.9	1.2	27.7	27.4	18.8	7.2
28	0.0	3.1	5.6	2.9	0.1	4.5	9.3	4.6	3.0
29	0.0	0.0	0.8	0.3	0.0	1.1	11.2	4.1	8.6
$\bar{x}$ HT	0.6	3.1	2.6	2.1	1.6	9.5	18.7	9.9	4.5
30	0.1	4.7	0.0	1.6	4.7	14.0	23.5	14.1	4.7
31	0.0	0.0	0.2	0.1	1.0	4.3	32.7	12.7	4.9

Table 32 (Continued)

Entry	% Root lodging at rates (1000 plants per acre) 12	18	24	Mean	% Stalk lodging at rates (1000 plants per acre) 12	18	24	Mean	% Dropped ears mean
32	0.1	1.2	0.0	0.4	2.2	19.1	27.6	16.3	1.7
33	0.2	15.0	4.8	6.7	7.8	8.0	11.4	9.1	5.8
34	0.0	0.0	3.8	1.3	2.7	5.5	11.9	6.7	1.2
35	0.0	0.8	2.5	1.1	0.0	10.6	9.6	6.7	3.7
36	0.0	2.4	0.9	1.1	3.1	2.2	18.4	7.9	7.6
37	0.0	0.2	0.0	0.1	0.0	3.6	5.2	2.9	5.3
38	0.1	2.5	1.6	1.4	2.4	16.0	42.7	20.4	6.9
39	0.0	0.8	0.3	0.4	0.0	4.5	8.6	4.4	8.1
40	3.3	3.4	5.3	4.0	15.0	21.6	59.0	31.9	4.2
41	0.0	5.7	3.1	2.9	1.1	1.1	12.0	4.7	6.0
42	0.0	0.0	3.2	1.1	0.3	13.5	27.4	13.7	5.1
43	0.0	1.7	7.3	3.0	7.3	14.4	21.2	14.3	5.3
44	0.0	11.5	0.2	3.9	6.3	11.2	21.3	12.9	5.2
45	0.0	0.0	0.1	0.0	3.5	4.7	14.7	7.6	3.8
$\bar{x}$ LP	0.2	3.1	2.1	1.8	3.6	9.6	21.7	11.6	5.0
46	0.1	8.2	6.2	4.8	9.7	32.9	33.7	25.4	1.0
47	0.2	0.0	1.3	0.5	3.9	18.7	23.1	15.2	8.6
48	0.0	7.6	13.6	7.1	0.0	2.4	12.2	4.9	3.6
49	0.0	2.1	0.3	0.8	0.0	19.9	30.4	16.8	5.5
50	0.0	0.0	5.8	1.9	3.8	10.5	24.0	12.8	3.0
51	3.0	2.9	0.0	2.0	0.5	15.6	19.5	11.9	4.5
52	0.0	0.0	0.1	0.0	4.4	11.2	21.6	12.4	4.4
53	0.0	2.1	0.1	0.7	0.0	8.6	28.0	12.2	2.4
54	0.3	0.0	0.0	0.1	0.5	5.6	25.8	10.6	3.9
55	0.0	0.9	0.0	0.3	1.6	3.3	8.7	4.5	8.2
56	0.1	1.3	0.0	0.5	1.2	6.8	18.3	8.8	2.5
57	0.0	0.9	0.2	0.4	3.8	16.4	28.3	16.2	8.6
58	0.2	0.0	0.0	0.1	1.9	6.4	17.7	8.7	8.2
59	0.0	4.3	4.8	3.0	2.5	13.2	23.7	13.1	6.8
60	0.0	0.4	0.2	0.2	0.5	4.6	12.3	5.8	7.7
61	0.0	2.0	1.8	1.3	7.7	9.3	18.5	11.8	8.7
$\bar{x}$ HP	0.2	2.0	2.2	1.5	2.6	11.6	21.6	11.9	5.5
M14	5.0	9.5	12.2	8.9	2.1	13.1	15.3	10.2	3.3
C103	0.0	0.6	0.5	0.4	0.1	4.4	20.0	8.2	3.7
M14xC103	0.1	1.6	0.0	0.6	3.1	5.6	19.6	9.4	3.7
$\bar{x}$ checks	1.7	3.9	4.2	3.3	1.8	7.7	18.3	9.3	3.6
Grand Mean	0.3	2.8	2.8	2.0	2.6	9.9	20.3	10.9	4.7

Table 33. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 4 groups of selections from M14 x C103 tested at 3 population levels in experiment 79 near Hampton, Iowa, 1964, with linear and quadratic yield regressions, R_{ℓ} and R_q across population rates

Groups of selections	Yield-cwt/acre at rates (1000 plants/acre) 12	18	24	Mean	R_{ℓ}	R_q	% H_2O	% Barren stalks at rate 24000
E	63.4	70.7	74.0	69.4	+5.30	-0.67	23.3	1.9
LT	59.1	65.8	59.2	61.4	+0.05	-2.22	23.8	2.8
HT	61.4	68.0	64.5	64.6	+1.55	-1.68	24.5	2.6
LP	59.5	62.8	59.1	60.5	-0.20	-1.17	23.3	4.2
HP	62.4	67.7	60.5	63.5	-0.95	-2.08	22.9	4.3
M14	54.0	57.6	62.0	57.9	+4.00	+0.13	23.8	2.8
C103	52.3	52.9	51.5	52.2	-0.40	-0.33	25.0	10.3
M14 x C103	62.6	61.3	52.4	58.8	-5.10	-1.26	24.4	3.5
$\bar{x}$	60.6	65.8	61.1	62.5	+0.25	-1.65	23.6	4.1

Table 34. Agronomic data of (WF x I205) testcrosses of M14 x C103, M14, C103, and 4 groups of selections from M14 x C103 tested at 3 population levels in experiment 79 near Hampton, Iowa, 1964

Groups of selections	Root lodging at rates (1000 plants/acre) 12	18	24	Mean	Stalk lodging at rates (1000 plants/acre) 12	18	24	Mean	% Dropped ears mean
E	0.0	10.6	6.1	5.6	3.4	9.3	20.3	11.0	2.3
LT	0.1	3.2	3.7	2.3	2.4	9.2	19.2	10.3	4.4
HT	0.6	3.1	2.6	2.1	1.6	9.5	18.7	9.9	4.5
LP	0.2	3.1	2.1	1.8	3.6	9.6	21.7	11.6	5.0
HP	0.2	2.0	2.2	1.5	2.6	11.6	21.6	11.9	5.5
M14	5.0	9.5	12.2	8.9	2.1	13.1	15.3	10.2	3.3
C103	0.0	0.6	0.5	0.4	0.1	4.4	20.0	8.2	3.7
M14 x C103	0.1	1.6	0.0	0.6	3.1	5.6	19.6	9.4	3.7
Mean	0.3	2.8	2.8	2.0	2.6	9.9	20.3	10.9	4.7

Table 35. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 61 selections from M14 x C103 tested at 3 population levels in experiment 80 at the Agronomy Farm, Ames, Iowa, 1964, with linear and quadratic yield regressions, R_ℓ and R_q, across population rates

Entry	1961 Nursery row number of selections	Yield-cwt/acre at rates (1000 plants per acre) 12	18	24	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at rate 24000
1	2205-11	62.0	64.5	63.0	63.2	+0.50	-0.67	21.4	7.1
2	2213-62	62.9	68.6	60.0	63.8	-1.45	-2.38	19.3	0.9
3	2223-44	64.3	64.4	62.0	63.6	-1.15	-0.42	23.0	5.5
$\bar{x}$ Elite		63.1	65.8	61.7	63.5	-0.70	-1.13	21.2	4.5
4	2207-55	62.6	71.4	65.8	66.6	+1.60	-2.40	25.5	2.6
5	2208-57	65.3	73.5	64.7	67.8	-0.30	-2.83	22.9	8.9
6	2209-13	64.1	60.5	63.9	62.8	-0.10	+1.17	21.1	2.7
7	2211-105	61.3	68.1	69.1	66.2	+3.90	-0.97	20.3	2.7
8	2212-92	63.4	70.7	62.8	65.6	-0.30	-2.53	21.8	8.5
9	2214-64	64.0	71.1	62.4	65.8	-0.80	-2.63	20.7	4.5
10	2217-66	63.9	68.2	61.1	64.4	-1.40	-1.90	23.5	0.9
11	2218-67	59.7	66.7	62.8	63.1	+1.55	-1.82	21.2	0.8
12	2219-95	57.4	68.8	60.9	62.4	+1.75	-3.22	22.9	5.0
13	2224-74	61.5	67.0	67.2	65.2	+2.85	-0.88	22.0	5.1
14	2225-21	66.4	64.2	58.1	62.9	-4.15	-0.65	21.2	0.9
15	2227-78	65.7	70.0	65.0	66.9	-0.35	-1.55	21.0	5.3
16	2230-117	65.3	63.7	64.9	64.6	-0.20	+0.47	20.0	2.6
$\bar{x}$ LT		63.1	68.0	63.7	64.9	+0.30	-1.53	21.8	3.9
17	2212-60	62.4	69.3	58.1	63.3	-2.15	-3.02	22.2	3.5
18	2227-49	66.5	70.1	68.2	68.3	+0.85	-0.92	22.0	0.0
19	2234-152	58.9	67.7	62.8	63.1	+1.95	-2.28	20.9	4.7

Table 35 (Continued)

Entry	1961 Nursery row number of selections	Yield-cwt/acre at rates (1000 plants per acre) 12	18	24	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at rate 24000
20	2235-153	51.2	47.4	59.1	52.6	+3.95	+2.58	22.5	0.0
21	2236-195	60.2	67.4	60.9	62.8	+0.36	-2.28	22.3	3.5
22	2237-170	64.8	67.5	56.6	63.0	-4.10	-2.27	20.0	1.9
23	2238-196	62.2	65.3	63.3	63.6	+0.55	-0.85	21.4	1.0
24	2239-183	66.9	63.8	58.9	63.2	-4.00	-0.30	25.7	6.9
25	2244-129	64.0	69.4	68.1	67.2	+2.05	-1.12	20.6	3.5
26	2246-127	64.6	67.4	54.5	62.2	-5.05	-2.62	22.1	0.9
27	2247-201	65.5	63.2	64.9	64.5	-0.30	+0.67	22.1	7.0
28	2250-193	63.4	68.3	61.0	64.2	-1.20	-2.03	22.2	4.4
29	2252-164	63.9	67.3	58.9	63.4	-2.50	-1.97	25.1	11.1
$\bar{x}$ HT		62.6	65.7	61.2	63.2	-0.70	-1.27	22.2	3.7
30	1968	59.8	74.9	65.0	66.6	+2.60	-4.17	22.9	1.0
31	1980	59.6	77.3	58.0	65.0	-0.80	-6.17	18.5	2.6
32	1985	54.7	62.7	49.0	55.5	-2.85	-3.62	18.9	5.1
33	1987	57.6	55.7	51.9	55.1	-2.85	-0.32	20.9	9.4
34	1992	64.0	60.0	52.0	58.7	-6.00	-0.67	22.3	6.8
35	1996	67.7	58.0	37.8	54.5	-14.95	-1.75	21.5	12.6
36	2003	63.3	67.4	61.9	64.2	-0.70	-1.60	21.5	0.9
37	2004	56.0	58.8	62.2	59.0	+3.10	+0.10	17.3	11.0
38	2006	64.4	68.8	57.8	63.7	-3.30	-2.57	23.6	0.0
39	2013	64.6	64.5	63.8	64.3	-0.40	-0.10	19.2	8.0
40	2014	62.4	71.9	56.9	63.7	-2.75	-4.08	24.6	4.5
41	2017	58.7	50.0	40.9	49.9	-8.90	-0.07	21.4	8.5
42	2019	63.2	71.6	62.3	65.7	-0.45	-2.95	20.7	4.2
43	2021	65.2	75.2	74.5	71.6	+4.65	-1.78	21.5	2.6
44	2033	69.0	73.2	63.3	68.5	-2.85	-2.35	21.7	4.4

Table 35 (Continued)

Entry	1961 Nursery row number of selections	Yield-cwt/acre at rates (1000 plants per acre) 12	18	24	Mean	R_{ℓ}	R_q	% H_2O	% Barren stalks at rate 24000
45	2034	64.7	70.7	63.9	66.4	-0.40	-2.13	22.2	4.5
$\bar{x}$ LP		62.2	66.3	57.6	62.0	-2.30	-2.13	21.2	5.4
46	2040	59.2	62.5	51.4	57.7	-3.90	-2.40	19.1	5.0
47	2044	54.1	63.3	58.3	58.6	+2.10	-2.36	21.1	5.1
48	2047	62.8	62.0	52.4	59.1	-5.20	-1.47	18.5	5.9
49	2052	66.9	73.8	68.8	69.8	+0.95	-1.98	23.0	1.8
50	2062	66.9	68.3	57.9	64.4	-4.50	-1.97	25.0	7.0
51	2064	60.8	64.9	55.3	60.3	-2.75	-2.28	20.8	5.2
52	2066	59.7	71.2	61.7	64.2	+1.00	-3.50	19.7	2.0
53	2067	67.1	64.2	52.2	61.2	-7.45	-1.52	21.5	4.5
54	2070	57.5	58.6	56.1	57.4	-0.70	-0.60	17.5	3.5
55	2074	57.5	58.5	57.4	57.8	-0.05	-0.35	19.7	1.9
56	2080	67.8	70.5	61.5	66.6	-3.15	-1.95	24.3	5.0
57	2083	63.7	61.3	59.5	61.5	-2.10	+0.10	22.1	0.9
58	2088	61.2	71.0	69.6	67.3	+4.20	-1.87	22.7	7.0
59	2094	63.4	71.1	58.6	64.4	-2.40	-3.37	22.2	3.7
60	2100	68.0	69.4	65.6	67.7	-1.20	-0.87	21.4	4.4
61	2104	58.6	63.5	58.1	60.1	-0.25	-1.72	19.9	5.0
$\bar{x}$ HP		62.2	65.9	59.0	62.4	-1.60	-1.77	21.2	4.2
M14		53.6	51.7	54.4	53.2	+0.40	+0.77	19.0	4.8
C103		52.8	63.6	54.2	56.9	+0.70	-3.37	23.2	6.7
M14 x C103		62.8	66.9	62.2	64.0	-0.30	-1.47	21.4	2.6
$\bar{x}$ checks		56.4	60.7	56.9	58.0	+0.25	-1.35	21.2	4.7
Grand $\bar{x}$		62.2	66.1	60.1	62.8	-1.05	-1.65	21.5	4.4

Table 36. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 61 selections from M14 x C103 tested at 3 population levels in experiment 80 at the Agronomy Farm, Ames, Iowa, 1964

Entry	% Root lodging at rates (1000 plants per acre) 12	18	24	Mean	% Stalk lodging at rates (1000 plants per acre) 12	18	24	Mean	% Dropped ears mean
1	61.1	35.7	55.5	50.8	1.2	8.4	14.5	8.0	4.1
2	34.0	43.8	50.9	42.9	3.7	7.9	37.0	16.2	1.6
3	24.0	46.9	42.5	37.8	4.7	3.5	31.9	13.4	2.2
$\bar{x}$ Elite	39.7	42.1	49.6	43.8	3.2	6.6	27.8	12.5	2.6
4	25.7	42.2	63.6	43.8	2.0	21.8	9.8	11.2	1.6
5	16.3	20.7	18.9	18.6	2.4	26.3	36.7	21.8	3.8
6	35.8	37.0	37.2	36.7	3.4	14.6	20.3	12.8	3.2
7	27.4	42.2	49.5	39.7	2.0	6.9	28.4	12.4	2.9
8	30.3	13.9	51.6	31.9	0.0	5.1	20.8	8.6	4.6
9	9.4	40.2	22.8	24.1	3.9	7.4	35.6	15.6	2.1
10	25.8	54.9	40.1	40.3	1.5	6.6	54.5	20.9	4.2
11	18.7	29.4	15.0	21.0	5.5	13.0	47.2	21.9	2.9
12	8.1	34.0	27.8	23.3	1.7	14.9	53.5	23.4	0.6
13	49.4	60.1	31.4	47.0	0.0	6.0	40.9	15.6	0.7
14	21.9	32.5	39.5	31.3	1.7	14.2	26.9	14.3	2.7
15	17.9	39.4	36.7	31.3	0.0	12.0	28.9	13.6	4.8
16	15.2	26.6	43.3	28.4	0.2	4.0	19.0	7.7	1.6
$\bar{x}$ LT	23.2	36.4	36.7	32.1	1.9	11.7	32.5	15.4	2.7
17	20.7	39.2	45.3	35.1	3.6	7.7	18.1	9.8	1.2
18	18.5	29.4	23.8	23.9	0.0	8.8	43.5	17.4	2.0
19	27.0	41.8	41.8	36.9	0.1	9.4	29.2	12.9	1.8
20	31.2	29.7	52.8	37.9	0.0	10.1	11.0	7.0	3.3
21	8.8	15.8	22.2	15.6	3.0	7.9	29.2	13.4	2.1
22	40.9	59.7	64.8	55.1	2.0	13.8	24.1	13.3	4.5
23	22.6	56.6	32.7	37.3	1.5	7.0	44.1	17.5	5.9
24	25.9	47.2	35.2	36.1	2.4	16.3	39.3	19.3	2.0
25	20.1	29.4	19.7	23.1	1.5	11.6	23.4	12.2	5.9
26	7.9	33.6	45.1	28.9	1.7	20.3	36.0	19.3	2.3
27	19.0	25.4	34.9	26.4	0.0	14.8	31.6	15.5	5.2
28	47.3	72.0	59.8	59.7	0.6	5.0	17.5	7.7	2.8
29	13.8	33.1	30.3	25.7	2.2	11.5	18.5	10.7	2.3
$\bar{x}$ HT	23.4	39.5	39.1	34.0	1.4	11.1	28.1	13.5	3.2
30	37.3	29.4	36.5	34.4	5.0	11.8	13.9	10.2	2.1
31	19.2	45.4	25.9	30.2	9.2	10.1	43.6	21.0	3.0

Table 36 (Continued)

Entry	% Root lodging at rates (1000 plants per acre) 12	18	24	Mean	% Stalk lodging at rates (1000 plants per acre) 12	18	24	Mean	% Dropped ears mean
32	16.6	12.1	25.6	18.1	0.0	16.6	26.3	14.3	0.6
33	48.7	52.1	47.4	49.4	1.7	16.2	30.0	16.0	3.5
34	35.3	33.5	54.4	41.1	0.0	17.3	30.3	15.9	2.1
35	26.3	11.8	14.9	17.7	3.6	9.4	27.4	13.5	5.0
36	7.7	17.6	14.8	13.4	8.3	9.9	36.0	18.1	2.6
37	20.5	17.7	24.4	20.9	1.5	6.7	5.0	4.4	4.1
38	29.3	35.0	32.4	32.2	5.6	13.1	31.7	16.8	6.9
39	16.4	18.9	23.2	19.5	0.0	4.1	21.1	8.4	4.9
40	24.4	48.2	18.7	30.4	12.2	25.0	66.2	34.5	4.1
41	22.8	26.7	33.3	27.6	3.8	9.8	8.1	7.2	3.0
42	18.3	28.4	39.5	28.7	8.6	19.1	38.6	22.1	6.3
43	24.2	28.8	21.2	24.7	11.0	10.7	43.2	21.6	2.9
44	23.4	42.3	20.7	28.8	3.4	6.4	42.7	17.5	6.0
45	25.5	43.9	34.8	34.7	0.0	3.9	50.6	18.2	2.4
$\bar{x}$ LP	24.7	30.7	29.2	28.2	4.6	11.9	32.2	16.2	3.7
46	43.4	52.1	53.6	49.7	15.5	17.2	21.5	18.1	2.9
47	20.6	31.2	38.2	30.0	1.6	16.1	42.2	20.0	1.8
48	47.9	19.5	44.2	37.2	0.0	13.6	18.9	10.8	2.3
49	12.2	23.0	4.8	13.3	3.1	30.8	60.4	31.4	3.3
50	31.7	56.3	78.0	55.3	4.0	8.3	13.0	8.4	2.1
51	30.0	26.5	42.3	32.9	3.4	23.4	30.5	19.1	3.2
52	55.5	27.8	42.7	42.0	0.0	14.9	36.1	17.0	0.1
53	48.1	25.5	49.5	41.0	1.6	12.2	17.7	10.5	2.2
54	31.3	49.6	31.5	37.5	0.0	22.2	56.1	26.1	1.8
55	9.5	25.3	23.5	19.4	2.3	11.7	23.0	12.3	4.1
56	19.9	33.0	34.0	29.0	0.0	7.8	25.2	11.0	3.6
57	32.2	27.1	28.5	29.3	0.0	12.2	34.2	15.5	4.9
58	12.6	26.3	39.8	26.2	2.0	10.1	23.8	12.0	4.4
59	42.7	28.7	31.8	34.4	6.5	18.5	29.7	18.2	4.6
60	27.3	4.1	11.3	14.2	3.5	8.9	22.8	11.7	6.0
61	17.6	21.4	36.1	25.0	0.1	8.3	35.8	14.7	3.8
$\bar{x}$ HP	30.2	29.8	36.9	32.3	2.7	14.8	30.7	16.1	3.2
M14	76.8	68.7	41.2	62.2	0.0	0.0	27.0	9.0	1.4
C103	28.7	15.2	14.4	19.4	3.8	17.2	29.2	16.7	2.4
M14xC103	14.2	35.4	38.0	29.2	1.4	19.1	31.3	17.3	3.8
$\bar{x}$ checks	39.9	39.8	31.2	36.9	1.7	12.1	29.2	14.3	2.5
Grand $\bar{x}$	26.9	34.4	35.7	32.3	2.7	12.2	30.7	15.2	3.1

Table 37. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 4 groups of selections from M14 x C103 tested at 3 population levels in experiment 80 at the Agronomy Farm, Ames, Iowa, 1965, with linear and quadratic yield regressions, R_ℓ and R_q, across population rates

Groups of selections	Yield-cwt/acre at rates (1000 plants/acre) 12	18	24	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at rate 24000
E	63.1	65.8	61.7	63.5	-0.70	-1.13	21.2	4.5
LT	63.1	68.0	63.7	64.9	+0.30	-1.53	21.8	3.9
HT	62.6	65.7	61.2	63.2	-0.70	-1.27	22.2	3.7
LP	62.2	66.3	57.6	62.0	-2.30	-2.13	21.2	5.4
HP	62.2	65.9	59.0	62.4	-1.60	-1.77	21.2	4.2
M14	53.6	51.7	54.4	53.2	+0.40	+0.77	19.0	4.8
C103	52.8	63.6	54.2	56.9	+0.70	-3.37	23.2	6.7
M14 x C103	62.8	66.9	62.2	64.0	-0.30	-1.47	21.4	2.6
$\bar{x}$	62.2	66.1	60.1	62.8	-1.08	-1.73	21.5	4.4

Table 38. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 4 groups of selections from M14 x C103 tested at 3 population levels in experiment 80 at the Agronomy Farm, Ames, Iowa, 1964

Groups of selections	Root lodging at rates (1000 plants/acre) 12	18	24	Mean	Stalk lodging at rates (1000 plants/acre) 12	18	24	Mean	% Dropped ears mean
E	39.7	42.1	49.6	43.8	3.2	6.6	27.8	12.5	2.6
LT	23.2	36.4	36.7	32.1	1.9	11.7	32.5	15.4	2.7
HT	23.4	39.5	39.1	34.0	1.4	11.1	28.1	13.5	3.2
LP	24.7	30.7	29.2	28.2	4.6	11.9	32.2	16.2	3.7
HP	30.2	29.8	36.9	32.3	2.7	14.8	30.7	16.1	3.2
M14	76.8	68.7	41.2	62.2	0.0	0.0	27.0	9.0	1.4
C103	28.7	15.2	14.4	19.4	3.8	17.2	29.2	16.7	2.4
M14 x C103	14.2	35.4	38.0	29.2	1.4	19.1	31.3	17.3	3.8
Mean	25.5	34.4	35.7	32.3	2.7	12.2	30.7	15.2	3.1

Table 39. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 61 selections from M14 x C103 tested at 3 population levels in experiment 81 near Ankeny, Iowa, 1964, with linear and quadratic yield regressions, R_ℓ and R_q across population rates

Entry	1961 Nursery row numbers of selections	Yield-cwt/acre at rates (1000's plants per acre) 12	18	24	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at rate 24000
1	2205-11	59.2	61.3	64.1	61.5	+2.45	+0.12	19.8	2.5
2	2213-62	56.2	60.8	50.1	55.7	-3.05	-2.55	19.2	4.3
3	2223-44	57.3	55.5	47.3	53.4	-5.00	-1.07	21.5	5.2
$\bar{x}$ Elite		57.6	59.2	53.8	56.9	-1.90	-1.17	20.2	4.0
4	2207-55	56.2	49.1	47.0	50.8	-4.60	+0.83	23.6	7.0
5	2208-57	55.9	53.4	51.4	53.6	-2.25	+0.08	19.5	6.2
6	2209-13	58.5	59.3	47.1	55.0	-5.70	-2.17	20.5	8.7
7	2211-105	55.0	54.6	54.5	54.7	-0.25	+0.05	19.3	4.2
8	2212-92	57.2	55.3	35.8	49.4	-10.70	-2.93	20.4	11.7
9	2214-64	55.3	56.8	42.1	51.4	-6.60	-2.70	20.6	7.0
10	2217-66	53.1	58.4	55.4	55.6	+1.15	-1.38	22.9	5.1
11	2218-67	52.2	61.6	46.1	53.3	-3.05	-4.15	20.2	3.5
12	2219-95	54.1	53.9	50.6	52.9	-1.75	-0.52	21.3	7.7
13	2224-74	60.1	50.6	42.4	51.0	-8.85	+0.22	22.1	4.2
14	2225-21	53.8	54.3	34.4	47.5	-9.70	-3.40	20.1	5.1
15	2227-78	62.4	58.5	55.7	58.9	-3.35	+0.18	19.8	2.5
16	2230-117	52.7	52.7	43.1	49.5	-4.80	-1.60	19.0	8.0
$\bar{x}$ LT		55.9	55.3	46.6	52.6	-4.65	-1.35	20.7	6.2
17	2212-60	50.0	49.8	50.2	50.0	+0.10	+0.10	21.3	6.2
18	2227-49	58.8	62.8	53.6	58.4	-2.60	-2.20	21.1	5.2
19	2234-152	60.4	49.2	50.5	53.4	-4.95	+2.08	20.5	9.2

Table 39 (Continued)

Entry	1961 Nursery row numbers of selections	Yield-cwt/acre at rates (1000's plants per acre) 12	18	24	Mean	R_{ℓ}	R_q	% H_2O	% Barren stalks at rate 24000
20	2235-153	47.0	49.3	47.1	47.8	+0.05	-0.75	20.7	3.0
21	2236-195	52.6	56.1	48.8	52.5	-1.90	-1.80	20.3	7.1
22	2237-170	53.7	58.7	53.5	55.3	-0.10	-1.70	20.5	5.2
23	2238-196	56.9	56.4	48.1	53.8	-4.40	-1.30	20.0	6.2
24	2239-183	56.5	63.0	45.7	55.1	-5.40	-3.97	23.8	6.9
25	2244-129	64.8	60.1	46.0	57.0	-9.40	-1.57	19.6	9.5
26	2246-127	53.9	54.7	36.9	48.5	-8.50	-3.10	20.8	3.4
27	2247-201	60.4	59.1	41.8	53.8	-9.30	-2.67	22.1	11.2
28	2250-193	50.2	54.8	51.1	52.0	+0.45	-1.38	21.2	2.5
29	2252-164	52.9	57.7	42.9	51.2	-5.00	-3.27	23.2	9.2
$\bar{x}$ HT		55.2	56.3	47.4	53.0	-3.90	-1.67	21.2	6.5
30	1968	50.6	57.0	56.3	54.6	+2.85	-1.18	21.9	4.2
31	1980	49.4	53.2	50.5	51.0	+0.55	-1.08	17.8	1.8
32	1985	43.3	51.9	32.6	42.6	-5.35	-4.65	18.8	10.7
33	1987	51.6	57.7	57.0	55.4	+2.70	-1.13	20.0	3.4
34	1992	56.2	54.8	48.9	53.3	-3.65	-0.75	20.3	12.6
35	1996	55.5	40.5	27.0	41.0	-14.25	+0.25	19.8	15.8
36	2003	44.0	59.3	38.3	47.2	-2.85	-6.05	19.8	10.4
37	2004	46.8	43.6	41.4	43.9	-2.70	+0.17	18.4	8.0
38	2006	58.0	55.1	43.8	52.3	-7.10	-1.40	22.8	11.1
39	2013	51.1	49.7	49.4	50.1	-0.85	+0.18	18.6	1.7
40	2014	55.3	52.8	43.2	50.4	-6.05	-1.18	21.4	11.3
41	2017	48.7	49.2	38.1	45.3	-5.30	-1.93	21.4	12.8
42	2019	54.5	50.2	32.8	45.8	-10.85	-2.18	19.6	13.0
43	2021	57.8	63.9	56.7	59.5	-0.55	-2.22	19.6	5.2
44	2033	63.9	60.1	44.5	56.2	-9.70	-1.97	19.9	10.9

Table 39 (Continued)

Entry	1961 Nursery row numbers of selections	Yield-cwt/acre at rates (1000's plants per acre) 12	18	24	Mean	R_{ℓ}	R_q	% H_2O	% Barren stalks at rate 24000
45	2034	50.6	60.9	49.9	53.8	-0.35	-3.55	20.1	10.2
$\bar{x}$ LP		52.3	53.7	44.4	50.1	-3.95	-1.78	20.0	8.9
46	2040	50.4	53.5	45.5	49.8	-2.45	-1.85	18.8	11.1
47	2044	53.2	54.2	41.0	49.5	-6.10	-2.37	19.1	6.8
48	2047	50.7	54.2	51.5	52.1	+0.40	-1.03	17.0	3.4
49	2052	61.0	65.9	49.1	58.7	-5.95	-3.62	20.8	6.2
50	2062	60.3	51.2	53.2	54.9	-3.55	+1.85	23.2	3.5
51	2064	48.0	51.8	37.2	45.7	-5.40	-3.07	20.5	7.1
52	2066	58.5	56.9	48.0	54.5	-5.25	-1.22	19.3	12.6
53	2067	53.6	58.2	52.6	54.8	-0.50	-1.70	21.1	4.4
54	2070	51.7	52.6	55.7	53.3	+2.00	+0.37	17.6	2.6
55	2074	51.1	59.2	43.7	51.3	-3.70	-3.94	18.9	8.6
56	2080	52.1	56.4	51.7	53.4	-0.20	-1.50	22.2	7.6
57	2083	60.6	52.1	44.6	52.4	-8.00	+0.17	19.9	3.6
58	2088	55.8	63.3	66.5	61.9	+5.35	-0.72	21.0	2.7
59	2094	56.0	68.2	56.5	60.2	+0.25	-3.98	21.7	4.3
60	2100	60.9	66.5	48.4	58.6	-6.25	-3.95	20.8	16.1
61	2104	58.6	54.7	54.3	55.9	-2.15	+0.58	19.3	10.5
$\bar{x}$ HP		55.1	57.4	50.0	54.2	-2.55	-1.62	20.1	6.9
M14		44.5	41.4	48.0	44.6	+1.75	+1.62	19.0	5.7
C103		54.7	48.5	49.9	51.0	-2.40	+1.27	20.8	7.8
M14 x C103		54.6	52.9	39.6	49.0	-7.50	-1.93	20.8	7.5
$\bar{x}$ checks		51.3	47.6	45.8	48.2	-2.75	+0.32	20.2	7.0
Grand $\bar{x}$		54.5	55.5	47.4	52.4	-3.55	-1.51	20.4	7.1

Table 40. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 61 selections from M14 x C103 tested at 3 population levels in experiment 81 near Ankeny, Iowa, 1965

Entry	% Root lodging at rates (1000 plants per acre) 12	18	24	Mean	% Stalk lodging at rates (1000 plants per acre) 12	18	24	Mean	% Dropped ears mean
1	8.4	2.4	16.6	9.1	0.0	0.4	8.0	2.8	3.1
2	2.9	2.5	45.2	16.9	0.0	2.3	5.9	2.7	5.0
3	2.4	2.2	0.0	1.5	0.1	2.2	2.4	1.6	2.4
$\bar{x}$ Elite	4.6	2.7	20.6	9.2	0.0	1.6	5.4	2.6	3.5
4	1.5	1.2	16.6	6.4	3.3	3.8	0.8	2.6	6.2
5	4.6	2.2	1.4	2.7	0.0	0.9	5.6	2.2	6.2
6	3.5	0.0	17.6	7.0	0.0	0.0	4.3	1.4	3.9
7	17.7	2.2	0.0	6.6	0.0	7.2	6.3	3.5	4.3
8	2.0	0.0	0.4	0.8	0.0	1.5	4.1	1.9	2.7
9	1.5	0.0	4.3	1.9	3.3	2.6	1.9	2.9	6.1
10	4.4	0.0	13.1	5.8	1.6	2.3	5.8	3.9	5.6
11	2.0	1.1	3.0	2.0	3.5	8.8	6.6	6.3	5.6
12	1.0	0.0	5.5	2.2	0.0	5.9	6.3	4.1	0.3
13	10.0	8.1	26.4	14.8	1.7	2.2	9.4	4.4	1.1
14	12.2	2.3	6.5	7.0	0.0	7.8	1.0	2.9	3.6
15	0.3	0.0	3.9	1.4	3.4	1.6	2.3	2.4	2.4
16	0.0	0.0	1.2	0.4	1.7	0.5	2.2	1.5	1.9
$\bar{x}$ LT	4.7	1.2	7.7	4.5	1.4	3.5	4.4	3.1	3.8
17	1.0	0.0	10.0	3.7	0.0	2.0	6.4	2.8	1.9
18	0.0	0.0	10.4	3.5	0.0	4.3	4.1	2.8	4.1
19	0.3	3.3	5.2	2.9	0.0	5.4	1.9	2.4	3.2
20	13.0	2.7	31.5	15.7	6.8	3.3	3.4	4.5	3.6
21	2.9	0.0	11.8	4.9	1.6	1.9	2.1	1.8	3.7
22	4.3	2.2	1.8	2.8	0.0	1.8	10.5	4.1	4.0
23	10.0	0.0	3.1	4.4	0.0	1.8	5.0	2.3	6.5
24	0.0	5.6	14.0	6.5	0.1	3.8	2.7	2.2	0.8
25	5.7	0.0	4.2	3.3	0.0	3.7	9.6	4.4	3.7
26	10.9	2.1	1.1	4.7	0.0	1.0	3.7	1.6	3.6
27	7.6	11.4	13.0	10.7	0.0	5.7	4.9	3.5	9.9
28	2.6	4.3	14.8	7.2	3.4	4.2	2.4	3.3	1.9
29	8.2	1.2	5.2	4.9	0.0	3.5	3.2	2.2	5.4
$\bar{x}$ HT	5.1	2.5	9.7	5.8	0.9	3.3	4.6	2.9	4.0
30	0.2	0.0	0.0	0.1	1.7	0.0	4.6	2.1	2.6
31	0.0	0.0	1.9	0.6	0.0	6.1	7.5	4.5	3.7

Table 40 (Continued)

Entry	% Root lodging at rates (1000 plants per acre) 12	18	24	Mean	% Stalk lodging at rates (1000 plants per acre) 12	18	24	Mean	% Dropped ears mean
32	0.8	0.0	0.0	0.3	0.0	4.7	3.3	2.6	2.7
33	0.0	3.4	1.3	1.6	0.1	2.6	9.6	4.1	5.1
34	0.2	8.9	8.5	5.9	0.0	0.0	2.5	0.8	4.1
35	4.1	0.0	0.0	1.4	0.0	0.8	2.0	0.9	6.9
36	0.9	0.0	0.0	0.3	3.5	3.7	3.3	3.5	3.8
37	0.0	0.0	0.0	0.0	0.0	2.1	0.4	0.8	5.6
38	15.8	1.1	11.6	9.5	0.0	4.6	1.9	2.2	3.9
39	0.0	0.0	4.5	1.5	3.5	1.4	2.0	2.3	2.9
40	4.9	10.1	9.4	8.1	5.4	6.6	14.3	8.8	3.1
41	0.2	0.0	4.2	1.5	0.0	0.3	5.6	2.0	3.2
42	0.0	0.0	0.5	0.2	0.1	1.2	5.8	2.4	3.2
43	6.4	22.2	28.7	19.1	0.0	5.5	7.6	4.4	3.5
44	1.2	0.0	10.7	4.0	1.6	1.4	5.1	2.7	2.9
45	0.8	0.0	19.5	6.8	3.3	2.4	1.6	2.4	2.5
$\bar{x}$ LP	2.2	2.9	6.3	3.8	1.2	2.7	4.8	2.9	3.7
46	8.1	0.0	7.9	5.3	3.5	7.9	8.7	6.7	3.4
47	1.5	0.0	14.9	5.5	0.0	10.4	1.6	6.7	3.1
48	0.1	0.0	5.5	2.9	0.0	1.3	5.2	2.2	1.8
49	0.0	0.0	7.0	2.7	6.7	7.1	5.5	6.4	2.3
50	25.1	15.9	9.3	16.8	5.2	8.5	8.1	7.3	6.0
51	0.5	0.0	2.1	0.9	3.4	4.1	6.3	4.6	3.8
52	23.7	2.2	6.6	10.8	0.0	0.8	7.1	2.6	4.7
53	12.8	0.0	14.9	9.2	3.4	0.0	4.9	2.8	3.0
54	0.0	8.3	2.4	3.6	5.1	2.0	5.8	4.3	3.8
55	0.0	0.0	0.0	0.0	1.7	2.7	1.2	1.9	8.3
56	1.2	0.0	0.0	0.4	0.0	5.0	4.0	3.0	1.6
57	23.4	2.3	20.2	15.3	3.4	2.8	2.8	3.0	3.3
58	5.7	7.8	14.6	9.4	1.7	5.7	8.9	5.4	10.6
59	1.9	1.1	8.8	3.9	5.0	6.8	9.1	7.0	5.8
60	0.3	0.0	2.4	0.9	0.0	3.6	3.6	2.4	5.2
61	7.4	0.0	8.7	5.4	1.7	2.0	7.0	3.6	10.6
$\bar{x}$ HP	7.0	2.3	7.8	5.7	2.6	4.4	5.6	4.4	4.8
M14	3.6	3.4	11.2	6.1	1.6	11.6	5.0	6.1	3.4
C103	0.8	0.0	7.6	2.8	0.0	0.0	2.9	1.0	3.2
M14xC103	2.1	2.3	10.9	5.2	0.0	2.5	9.7	4.1	5.1
$\bar{x}$ checks	2.2	1.9	9.9	4.7	0.5	4.7	5.5	3.7	3.9
Grand $\bar{x}$	4.5	2.3	8.4	5.1	1.4	3.4	5.0	3.3	4.1

Table 41. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 4 groups of selections from M14 x C103 tested at 3 population levels in experiment 81 at Ankeny, Iowa, 1964, with linear and quadratic yield regressions, R_ℓ and R_q, across population rates

Groups of of selections	Yield-cwt/acre at rates (1000 plants/acre) 12	18	24	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at rate 24000
E	57.6	59.2	53.8	56.9	-1.90	-1.17	20.2	4.0
LT	55.9	55.3	46.6	52.6	-4.65	-1.35	20.7	6.2
HT	55.2	56.3	47.4	53.0	-3.90	-1.67	21.2	6.5
LP	52.3	53.7	44.4	50.1	-3.95	-1.78	20.0	8.9
HP	55.1	57.4	50.0	54.2	-2.55	-1.62	20.1	5.7
M14	44.5	41.4	48.0	44.6	+1.75	+1.62	19.0	5.7
C103	54.7	48.5	49.9	51.0	-2.40	+1.27	20.8	7.8
M14 x C103	54.6	52.9	39.6	49.0	-7.50	-1.93	20.8	7.0
$\bar{x}$	54.5	55.5	47.3	52.4	-3.58	-1.50	20.4	6.7

Table 42. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 4 groups of selections from M14 x C103 tested at 3 population levels in experiment 81 at Ankeny, Iowa, 1964

Groups of selections	Root lodging at rates (1000 plants/acre) 12	18	24	Mean	Stalk lodging at rates (1000 plants/acre) 12	18	24	Mean	% Dropped ears mean
E	4.6	2.7	20.6	9.2	0.0	1.6	5.4	2.6	3.5
LT	4.7	1.2	7.7	4.5	1.4	3.5	4.4	3.1	3.8
HT	5.1	2.5	9.7	5.8	0.9	3.3	4.6	2.9	4.0
LP	2.2	2.9	6.3	3.8	1.2	2.7	4.8	2.9	3.7
HP	7.0	2.3	7.8	5.7	2.6	4.4	5.6	4.4	4.8
M14	3.6	3.4	11.2	6.1	1.6	11.6	5.0	6.1	3.4
C103	0.8	0.0	7.6	2.8	0.0	0.0	2.9	1.0	3.2
M14 x C103	2.1	2.3	10.9	5.2	0.0	2.5	9.7	4.1	5.1
Mean	4.5	2.3	8.4	5.1	1.4	3.4	5.0	3.3	4.1

Table 43. Analyses of variance of grain yields, in cwt per acre, obtained in Experiments 79, 80 and 81 grown near Hampton, Ames and Ankeny, respectively, in 1964, showing the orthogonal subdivision of the entry and rates components and the interaction of entries x rates

Source	d.f.	Mean squares Ames	Ankeny	Hampton
Replications	1	29.6800	3257.2000	1387.4200
Rates (R)	2	1202.5875	2521.5653	1058.9742
Linear (R_{ℓ})	1	298.4256	3310.5000	19.1406
Quadratic (R_q)	1	2106.0870	1734.6000	2098.8075
Reps x rates	2	686.5582	1704.4653	872.0564
Entries	63	111.4466**	117.4756**	189.2285**
LT vs HT	1	123.1340*	6.1580	416.8269**
LP vs HP	1	5.9500	777.6300**	441.6533**
T vs P	1	301.8600**	31.4820	82.3850
E vs (P + T)	1	4.1000	335.0800**	821.3164**
Selections vs checks	1	434.8000**	336.1100**	727.8202**
Among E	2	0.6800	106.1666	13.8950
Among LT	12	18.4750	56.3683	87.0750**
Among HT	12	79.3800**	58.3225	153.2390**
Among LP	15	211.3173**	171.8626**	320.5460**
Among HP	15	96.5513**	107.8905**	116.6853**
Among checks	2	178.8160**	64.3200	75.2290
Entries x rates	126	33.5082**	47.9592*	49.6829**
Entries x R_{ℓ}	63	42.4937**	62.0493**	55.2189**
LT vs HT x R_{ℓ}	1	27.6652	10.7554	61.2264
LP vs HP x R_{ℓ}	1	15.3870	59.9550	18.0000
T vs P x R_{ℓ}	1	169.7552**	57.7662	110.2345*
E vs (P + T) x R_{ℓ}	1	4.8515	39.6557	317.9661**
Selections vs checks x R_{ℓ}	1	24.5285	9.7977	6.3182
Among E x R_{ℓ}	2	4.4100	59.7050	41.0133
Among LT x R_{ℓ}	12	16.7567	52.0317	37.3333
Among HT x R_{ℓ}	12	29.4583	52.2717	66.3666**
Among LP x R_{ℓ}	15	89.7420**	94.0133**	53.8572*
Among HP x R_{ℓ}	15	34.9987	51.8800	44.3765
Among checks x R_{ℓ}	2	0.2000	85.8650	82.8400
Entries x R_q	63	24.5107	33.8430	42.8867*
LT vs HT x R_q	1	5.1900	7.6295	19.2011
LP vs HP x R_q	1	14.0244	2.7344	83.6267
T vs P x R_q	1	53.3990	7.5635	15.5920
E vs (P + T) x R_q	1	10.0607	6.8608	40.8068
Selections vs checks x R_q	1	4.0769	125.0528	75.8348

Table 43 (Continued)

Source	d.f.	Mean squares Ames	Ankeny	Hampton
Among E x R_q	2	13.4300	21.4100	111.6811**
Among LT x R_q	12	20.5083	31.4700	43.2250
Among HT x R_q	12	28.9075	29.4516	34.8083
Among LP x R_q	15	37.3620	35.7433	39.6900
Among HP x R_q	15	11.6287	38.7007	46.6364
Among checks x R_q	2	51.3600	45.8750	6.0928
Pooled effective error	147	21.4601	36.3257	26.1291[a]
Total	383			

[a]146 d.f.

Table 44. Analysis of variance of grain moisture at harvest obtained in Experiments 79, 80 and 81 grown near Hampton, Ames and Ankeny respectively, in 1964, showing the orthogonal comparisons of entry and rate comparisons, and the interactions of entries and rates

Source	d.f.	Mean squares Ames	Ankeny	Hampton
Replications	1	14.30	4.08	30.82
Rates (R)	2	13.73	4.41	5.61
Linear (R_l)	1	24.87	8.55	11.22
Quadratic (R_q)	1	2.59	0.27	0.00
Reps x rates	2	7.72	5.92	7.44
Entries	63	19.49**	12.13**	21.81**
LT vs HT	1	5.77*	7.32**	15.70**
LP vs HP	1	0.03	0.21	4.10
T vs P	1	67.91**	69.49**	92.11**
E vs (P + T)	1	1.69	1.34	1.48
Selections vs checks	1	2.02	0.93	0.00
Among E	2	20.27**	8.21**	37.35**
Among LT	12	13.91**	11.57**	18.21**
Among HT	12	15.06**	8.79**	15.23**
Among LP	15	23.35**	10.83**	25.20**
Among HP	15	25.22**	16.55**	26.00**
Among checks	2	16.81**	6.85**	8.48**
Entries x rates	126	1.50	0.82	1.64
Entries x R_l	63	1.73	0.97	1.87
LT vs HT x R_l	1	0.53	1.43	2.62
LP vs HP x R_l	1	0.04	0.73	0.12
T vs P x R_l	1	3.70	0.00	1.41
E vs (P + T) x R_l	1	0.00	0.56	0.86
Selections vs checks x R_l	1	2.49	0.78	4.75
Among E x R_l	2	0.89	0.36	2.77
Among LT x R_l	12	1.41	0.74	1.87
Among HT x R_l	12	1.25	1.21	2.14
Among LP x R_l	15	0.78	1.17	2.04
Among HP x R_l	15	2.16	1.01	1.23
Among checks x R_l	2	0.92	0.42	2.24
Entries x R_q	63	1.14	0.69	1.37
LT vs HT x R_q	1	0.88	6.04**	0.88
LP vs HP x R_q	1	0.68	1.40	0.22

Table 44 (Continued)

Source	d.f.	Ames	Ankeny	Mean squares Hampton
T vs P x R_q	1	1.93	0.11	0.73
E vs (P + T) x R_q	1	1.59	0.05	0.28
Selections vs checks x R_q	1	0.00	0.10	0.00
Among E x R_q	2	0.08	0.82	3.24
Among LT x R_q	12	1.41	0.50	2.24
Among HT x R_q	12	1.25	0.81	1.94
Among LP x R_q	15	0.78	0.48	0.79
Among HP x R_q	15	1.51	0.54	1.00
Among checks x R_q	2	0.19	1.54	0.38
Pooled effective error	175[a]	1.34	0.80	1.25
Total	401			

[a]147 D.F.

Table 45. Analysis of variance of % grain moisture at harvest of data combined over experiments 79, 80 and 81, showing the orthogonal comparisons of entry and rates components and interactions involving entries, rates and locations

Source	d.f.	SS	MS	F
Locations	2	2006.23	1003.12	140.20**
Reps/loc error a	3	21.46	7.15	
Rates (R)	2	8.49	4.24	0.43
Linear (R_ℓ)	1	6.94	6.94	0.71
Quadratic (R_q)	1	1.55	1.55	0.16
Locations x rates	4	39.02	9.76	1.38
Error b	6	42.18	7.03	
Entries	63	3081.40	48.91	20.02**
LT vs HT	1	27.48	27.48	12.15**
LP vs HP	1	1.34	1.34	0.59
T vs P	1	228.22	228.22	100.89**
E vs (P + T)	1	4.48	4.48	1.98
Selections vs checks	1	0.35	0.35	0.15
Among E	2	119.37	59.69	26.39**
Among LT	12	465.50	38.79	17.15**
Among HT	12	436.26	36.35	16.08**
Among LP	15	787.38	52.49	23.21**
Among HP	15	956.73	63.78	28.20**
Among checks	2	54.29	27.15	12.00**
Entries x locations	126	285.04	2.26	2.00**
LT vs HT	2	1.31	0.65	0.57
LP vs HP	2	3.00	1.50	1.33
T vs P	2	1.29	0.65	0.57
E vs (P + T)	2	0.02	0.01	0.01
Selections vs checks	2	2.61	1.31	1.16
Among E	4	12.28	3.07	2.72
Among LT	24	58.68	2.44	2.16**
Among HT	24	32.66	1.36	1.12
Among LP	30	103.28	3.44	3.20**
Among HP	30	59.90	2.00	1.77*
Among checks	4	9.98	2.49	2.20
Entries x rates	126	182.16	1.45	1.15
Entries x R_ℓ	63	121.29	1.92	1.53
LT vs HT x R_ℓ	1	0.00	0.00	0.00
LP vs HP x R_ℓ	1	0.34	0.34	0.27
T vs P x R_ℓ	1	3.31	3.31	2.63

Table 45 (Continued)

Source	d.f.	SS	MS	F
E vs (P + T) x R_ℓ	1	1.14	1.14	0.91
Selections vs checks x R_ℓ	1	0.02	0.02	0.02
Among E x R_ℓ	2	3.30	1.65	1.31
Among LT x R_ℓ	12	30.49	2.54	2.02*
Among HT x R_ℓ	12	28.49	2.37	1.88
Among LP x R_ℓ	15	21.17	1.41	1.12
Among HP x R_ℓ	15	27.35	1.82	1.45
Among checks x R_ℓ	2	1.74	0.87	0.69
Entries x R_q	63	69.27	1.10	0.87
LT vs HT x R_q	1	1.63	1.63	1.29
LP vs HP x R_q	1	0.31	0.31	0.24
T vs P x R_q	1	0.45	0.45	0.36
E vs (P + T) x R_q	1	0.00	0.00	0.00
Selections vs checks x R_q	1	0.01	0.01	0.01
Among E x R_q	2	5.78	2.69	2.13
Among LT x R_q	12	10.04	0.83	0.66
Among HT x R_q	12	17.78	1.48	1.17
Among LP x R_q	15	7.32	0.49	0.39
Among HP x R_q	15	22.15	1.48	1.17
Among checks x R_q	2	0.80	0.40	0.32
Entries x rates x locations	252	317.66	1.26	1.11
Entries x locations x R_ℓ	126	179.81	1.43	1.26
LT vs HT x R_ℓ	2	4.58	2.29	2.02
LP vs HP x R_ℓ	2	0.55	0.28	0.24
T vs P x R_ℓ	2	1.80	0.90	0.79
E vs (P + T) x R_ℓ	2	0.28	0.14	0.12
Selections vs checks on R_ℓ	2	8.00	4.00	3.53**
Among E x R_ℓ	4	4.76	1.19	1.05
Among LT x R_ℓ	24	17.67	0.74	0.65
Among HT x R_ℓ	24	39.42	1.64	1.45
Among LP x R_ℓ	30	61.59	2.05	1.81
Among HP x R_ℓ	30	38.63	1.29	1.14
Among checks x R_ℓ	4	5.45	1.36	1.20
Entries x locations x R_q	126	136.42	1.08	0.95
LT vs HT x R_q	2	6.17	3.08	2.72
LP vs HP x R_q	2	2.30	1.15	1.01

Table 45 (Continued)

Source	d.f.	SS	MS	F
T vs P x R_q	2	2.77	1.38	1.22
E vs (P + T) x R_q	2	1.92	0.96	0.84
Selections vs checks x R_q	2	0.10	0.05	0.00
Among E x R_q	4	2.51	0.63	0.55
Among LT x R_q	24	39.74	1.66	1.46
Among HT x R_q	24	30.33	1.26	1.11
Among LP x R_q	30	23.44	0.78	0.69
Among HP x R_q	30	23.72	0.79	0.70
Among checks x R_q	4	3.42	0.85	0.76
Pooled average effective error	497	563.55	1.13	

Table 46. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 61 selections from M14 x C103 with linear and quadratic yield regressions, R_ℓ and R_q, across population rates

Entry	1961 Nursery row number of selections	Yield-cwt/acre at rates (1000's plant per acre) 12	18	24	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at rate 24000
1	2205-11	62.1	66.7	65.4	64.7	+1.65	-0.98	21.4	4.5
2	2213-62	60.7	68.4	61.3	63.4	+0.30	-2.47	19.8	2.3
3	2223-44	61.3	60.7	62.8	61.6	+0.75	+0.45	23.4	3.5
$\bar{x}$ Elite		61.4	65.3	63.2	63.3	+0.90	-1.00	21.5	3.4
4	2207-55	56.6	61.8	57.4	58.6	+0.40	-1.60	25.6	3.5
5	2208-57	61.2	61.7	57.7	60.2	-1.75	-0.75	22.1	7.9
6	2209-13	61.6	63.1	57.5	60.7	-2.05	-1.18	21.5	4.1
7	2211-105	57.8	64.6	61.9	61.4	+2.05	-1.58	20.7	2.6
8	2212-92	58.7	62.5	54.9	58.7	-1.90	-1.90	21.5	7.0
9	2214-64	56.2	63.9	49.9	56.7	-3.15	-3.61	21.4	6.0
10	2217-66	59.0	65.3	59.2	61.2	+0.10	-2.07	24.2	4.8
11	2218-67	58.0	68.1	56.7	60.9	-0.65	-3.58	21.1	2.6
12	2219-95	55.5	61.2	56.2	57.6	+0.35	-1.78	23.2	5.5
13	2224-74	61.6	61.4	55.8	59.6	-2.90	-0.90	22.6	3.1
14	2225-21	61.5	59.1	50.8	57.1	-5.35	-0.98	21.7	2.0
15	2227-78	63.8	65.5	63.2	64.2	-0.30	-0.67	21.6	2.6
16	2230-117	60.5	60.7	53.7	58.3	-3.40	-1.20	20.4	4.2
$\bar{x}$ LT		59.4	63.0	56.5	59.6	-1.45	-1.68	22.1	4.3
17	2212-60	58.8	60.7	57.5	59.0	-0.65	-0.85	22.2	3.5
18	2227-49	61.7	67.2	63.3	64.0	+0.80	-1.57	22.4	2.6
19	2234-152	62.4	62.0	56.8	60.4	-2.80	-0.80	21.6	5.7
20	2235-153	50.5	52.9	54.6	52.6	+2.05	-0.11	22.6	2.6

Table 46 (Continued)

Entry	1961 Nursery row number of selections	Yield-cwt/acre at rates (1000's plant per acre) 12	18	24	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at rate 24000
21	2236-195	57.3	61.2	57.6	58.7	+0.15	-1.25	22.3	3.8
22	2237-170	58.3	65.9	58.6	60.9	+0.15	-2.48	21.0	3.0
23	2238-196	61.8	67.1	61.7	63.5	-0.05	-1.78	21.6	3.4
24	2239-183	61.5	65.0	54.6	60.3	-3.45	-2.32	25.9	5.2
25	2244-129	63.7	60.4	55.5	59.8	-4.10	-0.27	21.2	6.7
26	2246-127	60.5	62.6	51.4	58.2	-4.55	-2.21	22.3	1.8
27	2247-201	62.8	66.4	61.0	63.4	-0.90	-1.50	22.9	6.6
28	2250-193	59.1	66.4	58.7	61.4	-0.20	-2.50	22.7	3.3
29	2252-164	58.4	65.5	59.0	61.0	+0.30	-2.27	25.2	7.6
$\bar{x}$ HT		59.8	63.3	57.7	60.2	-1.05	-1.52	22.6	4.3
30	1968	57.0	67.0	63.8	62.6	+3.40	-2.20	23.4	1.7
31	1980	55.8	65.6	56.3	59.2	+0.25	-3.18	18.9	2.3
32	1985	51.3	55.7	44.7	50.6	-3.30	-2.57	19.3	6.4
33	1987	56.5	59.7	55.4	57.2	-0.55	-1.25	21.5	5.7
34	1992	59.1	56.5	51.3	55.6	-3.90	-0.43	22.5	9.9
35	1996	58.1	45.3	32.7	45.4	-12.70	+0.03	21.6	12.3
36	2003	55.9	63.7	55.5	58.3	-0.20	-2.67	21.2	5.2
37	2004	52.2	50.2	52.5	51.6	+0.15	+0.72	18.9	8.7
38	2006	61.0	62.5	53.6	59.0	-3.70	-1.73	24.6	4.6
39	2013	59.2	60.7	58.2	59.4	-0.50	-0.67	19.7	3.5
40	2014	59.8	64.8	55.5	60.0	-2.15	-2.38	24.1	6.5
41	2017	54.3	53.7	44.8	51.0	-4.75	-1.38	22.6	10.0
42	2019	61.1	61.3	53.3	58.5	-3.90	-1.37	20.8	6.0
43	2021	60.7	72.5	68.1	67.1	+3.70	-2.70	21.1	3.5
44	2033	67.3	68.3	55.7	63.8	-5.80	-2.26	21.5	6.5

Table 46 (Continued)

Entry	1961 Nursery row number of selections	Yield-cwt/acre at rates (1000's plants per acre) 12	18	24	Mean	R_ℓ	R_q	% H_2O	% Barren stalks at rate 24000
45	2034	58.9	67.9	57.8	61.5	-0.55	-3.18	21.9	5.8
$\bar{x}$ LP		58.0	61.0	53.7	57.5	-2.15	-1.72	21.5	6.2
46	2040	58.4	61.3	50.4	56.7	-4.00	-2.30	19.4	5.6
47	2044	54.2	58.5	51.2	54.6	-1.50	-1.93	20.9	4.3
48	2047	58.8	60.1	58.2	59.0	-0.30	-0.53	18.1	3.1
49	2052	63.5	70.3	60.4	64.7	-1.55	-2.78	22.5	4.9
50	2062	62.3	61.8	58.1	60.7	-2.10	-0.53	25.0	6.7
51	2064	54.8	60.9	46.5	54.1	-4.15	-3.42	21.8	8.4
52	2066	60.9	66.1	56.5	61.1	-2.20	-2.46	20.1	7.1
53	2067	62.7	64.8	53.7	60.4	-4.50	-2.20	22.2	4.1
54	2070	55.6	59.2	59.7	58.2	+2.05	-0.52	18.6	2.3
55	2074	57.0	62.9	52.1	57.3	-2.45	-2.78	20.4	5.0
56	2080	61.4	63.9	58.5	61.2	-1.45	-1.32	24.1	6.3
57	2083	64.0	60.4	56.4	60.3	-3.80	-0.07	21.9	2.1
58	2088	61.1	71.3	71.0	67.8	+4.95	-1.75	22.7	3.8
59	2094	61.5	71.5	57.8	63.6	-1.85	-3.95	22.6	3.0
60	2100	62.5	67.7	55.2	61.8	-3.65	-2.95	21.8	8.1
61	2104	59.9	58.2	58.3	58.8	-0.80	+0.30	20.2	7.8
$\bar{x}$ HP		59.9	63.7	56.5	60.0	-1.70	-1.83	21.4	5.2
M14		50.7	50.2	54.8	51.9	+2.05	+0.85	20.6	4.4
C103		53.3	55.0	51.9	53.4	-0.70	-0.80	23.0	8.3
(M14xC103)		60.0	60.4	51.4	57.2	-4.30	-1.57	22.0	4.5
$\bar{x}$ checks		54.7	55.2	52.7	54.2	-1.00	-0.50	21.9	5.7
Grand $\bar{x}$		59.2	62.5	56.2	59.2	-1.50	-1.60	21.8	5.0

Table 47. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 61 selections from M14 x C103 at 3 population levels averaged over 3 locations in Iowa, 1964

Entry	% Root lodging at rates (1000 plants per acre) 12	18	24	Mean	% Stalk lodging at rates (1000 plants per acre) 12	18	24	Mean	% Dropped ears mean
1	23.2	17.2	27.9	22.8	1.9	6.6	13.4	7.3	2.8
2	29.0	21.5	33.6	28.0	2.7	7.3	15.3	8.4	3.0
3	8.8	16.4	14.9	13.4	2.0	3.5	14.8	6.8	2.6
$\bar{x}$ Elite	14.8	18.5	25.4	19.6	2.2	5.8	17.8	8.6	2.8
4	9.1	14.6	27.8	17.2	1.9	12.4	7.9	7.4	4.3
5	7.0	7.6	7.1	7.2	1.8	12.1	22.8	12.2	7.5
6	13.1	14.1	18.3	15.2	1.2	8.0	13.4	7.5	3.3
7	15.0	15.0	18.0	16.0	1.9	5.9	17.0	8.3	5.0
8	10.8	5.7	18.0	11.5	2.3	5.5	17.9	8.6	3.1
9	3.6	14.8	9.2	9.2	2.8	5.3	15.8	8.0	3.7
10	10.1	21.5	22.8	18.1	1.6	5.2	28.6	11.8	5.0
11	6.9	10.4	6.7	8.0	4.1	12.5	28.8	15.1	4.9
12	3.0	11.6	11.2	8.6	2.3	8.9	27.9	13.0	1.0
13	19.8	27.5	23.0	23.4	1.3	7.2	27.5	12.0	1.3
14	11.4	12.5	17.7	13.9	0.7	9.6	13.0	7.8	3.4
15	6.1	13.1	13.9	11.0	1.1	10.6	15.1	8.9	3.3
16	5.2	8.9	14.8	9.6	1.8	2.6	10.6	15.0	1.7
$\bar{x}$ LT	9.3	13.6	16.0	13.0	1.9	8.1	18.7	9.6	3.6
17	7.2	14.1	18.8	13.4	1.6	3.6	14.4	6.5	1.8
18	6.2	9.8	12.3	9.4	0.2	8.7	27.4	12.1	3.0
19	9.1	15.4	15.8	13.4	1.4	10.0	14.1	8.5	2.1
20	16.8	13.4	28.2	19.5	2.4	6.4	4.8	4.5	3.6
21	3.9	5.3	11.5	6.9	1.5	4.0	16.4	7.3	3.9
22	15.1	23.9	24.1	21.0	1.1	10.1	21.5	10.9	4.2
23	10.9	20.9	14.4	15.4	1.4	6.3	21.3	9.7	8.1
24	8.7	18.1	18.0	14.9	0.8	7.8	19.2	9.3	1.7
25	8.6	10.5	8.1	9.1	0.9	6.6	19.1	8.9	4.4
26	6.3	12.9	15.7	11.6	3.5	13.7	22.7	13.3	2.6
27	9.4	13.2	17.3	13.3	0.4	16.1	21.3	12.6	7.4
28	16.6	26.5	26.7	23.3	1.4	4.6	9.7	5.2	2.6
29	7.3	11.4	12.1	10.3	0.7	5.4	11.0	5.7	5.4
$\bar{x}$ HT	9.7	15.0	17.1	13.9	1.3	8.0	17.1	8.8	3.9
30	12.5	11.4	12.2	12.0	3.8	8.6	14.0	8.8	3.1
31	6.4	15.1	9.3	10.3	3.4	6.8	27.9	12.7	3.9
32	5.8	4.4	8.5	6.2	0.7	13.5	19.1	11.1	1.7

Table 47 (Continued)

Entry	% Root lodging at rates (1000 plants per acre) 12	18	24	Mean	% Stalk lodging at rates (1000 plants per acre) 12	18	24	Mean	% Dropped ears mean
33	16.3	23.5	17.8	19.2	3.2	8.9	17.0	9.7	4.8
34	11.8	14.1	22.2	16.0	0.9	7.6	14.9	7.8	2.5
35	10.1	4.2	5.8	6.7	1.2	6.9	13.0	7.0	5.2
36	2.9	6.7	5.2	4.9	5.0	5.3	19.2	9.8	4.7
37	6.8	6.0	8.1	7.0	0.5	4.1	3.5	2.7	5.0
38	15.1	12.9	15.2	14.4	2.7	11.2	25.4	13.1	5.9
39	5.5	6.6	9.3	7.1	1.2	3.3	10.6	5.0	5.3
40	10.9	20.6	11.1	14.2	10.9	17.7	46.5	25.0	3.8
41	7.7	10.8	13.5	10.7	1.6	3.7	8.6	4.6	4.1
42	6.1	9.5	14.4	10.0	3.0	11.3	23.9	12.7	4.9
43	10.2	17.6	19.1	15.6	6.6	10.2	24.0	13.6	3.9
44	8.2	17.9	10.5	12.2	3.8	6.3	23.0	11.0	4.7
45	8.8	14.6	18.1	13.8	2.3	3.7	22.3	9.4	2.9
$\bar{x}$ LP	9.0	12.2	12.2	11.1	3.1	8.1	15.5	8.9	4.1
46	17.2	20.1	22.6	20.0	9.6	19.3	21.3	16.7	2.4
47	7.4	10.4	18.1	12.0	1.8	15.1	22.3	13.1	4.5
48	16.0	9.0	21.1	15.4	0.0	5.8	12.1	6.0	2.6
49	4.1	8.4	4.0	5.5	3.3	19.3	32.1	18.2	3.7
50	18.9	24.1	31.0	24.7	4.3	9.1	15.0	9.5	3.7
51	11.2	9.8	14.8	11.9	2.4	14.4	18.8	11.9	3.8
52	26.4	10.0	16.5	17.6	1.5	9.0	21.6	10.7	3.1
53	20.3	9.2	21.5	17.0	1.7	6.9	16.9	8.5	2.5
54	10.5	19.3	11.3	13.7	1.9	9.9	29.2	13.7	3.2
55	3.2	8.7	7.8	6.6	1.9	5.9	11.0	6.3	6.9
56	7.1	11.4	11.3	9.9	0.4	6.5	15.8	7.6	2.6
57	18.5	10.1	16.3	15.0	2.4	10.5	21.8	11.6	5.6
58	6.2	11.4	18.1	12.9	1.9	7.4	16.8	8.7	7.7
59	14.9	11.4	15.1	13.8	4.7	12.8	20.8	12.8	5.7
60	9.2	1.5	4.6	5.1	1.3	5.7	12.9	6.6	6.3
61	8.3	7.8	15.5	10.5	3.2	6.5	20.4	10.0	7.7
$\bar{x}$ HP	12.5	11.4	15.6	13.2	2.6	10.3	19.3	10.7	4.5
M14	18.5	27.2	21.5	22.4	1.2	8.2	15.8	8.4	2.7
C103	9.8	5.3	7.5	7.5	1.3	7.2	17.4	8.6	3.1
M14xC103	5.5	13.1	16.3	11.6	1.5	9.1	20.2	10.3	4.2
$\bar{x}$ checks	14.6	15.2	15.1	15.0	1.3	8.2	17.7	9.1	3.3
Grand $\bar{x}$	10.6	13.2	15.6	13.1	2.2	8.5	18.7	9.8	4.0

Table 48. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 4 groups of selections from M14 x C103 tested at 3 population levels near Hampton, Ames, and Ankeny, Iowa, 1964, with linear and quadratic yield regressions, R_{ℓ} and R_q across population rates

Groups of selections	Yield-cwt/acre at rates (1000 plants/acre) 12	18	24	Mean	R_{ℓ}	R_q	% H_2O	% Barren stalks at rate 24000
E	61.4	65.3	63.2	63.3	+0.90	-1.00	21.5	3.4
LT	59.4	63.0	56.5	59.6	-1.45	-1.68	22.1	4.3
HT	59.8	63.3	57.7	60.2	-1.05	-1.52	22.6	4.3
LP	58.0	61.0	53.7	57.5	-2.15	-1.72	21.5	6.2
HP	59.9	63.7	56.5	60.0	-1.70	-1.83	21.4	5.2
M14	50.7	50.2	54.8	51.9	+2.05	+0.85	20.6	4.4
C103	53.3	55.0	51.9	53.4	-0.70	-0.80	23.0	8.3
M14 x C103	60.0	60.4	51.4	57.2	-4.30	-1.57	22.0	4.5
$\bar{x}$	59.1	62.5	56.2	59.2	-1.50	-1.60	21.8	5.0

Table 49. Agronomic data of (WF9 x I205) testcrosses of M14 x C103, M14, C103, and 4 groups of selections from M14 x C103 tested at 3 population levels near Hampton, Ames, and Ankeny, Iowa, 1964

Groups of selections	Root lodging at rates (1000 plants/acre) 12	18	24	Mean	Stalk lodging at rates (1000 plants /acre) 12	18	24	Mean	% Dropped ears mean
E	14.8	18.5	25.4	19.6	2.2	5.8	17.8	8.6	2.8
LT	9.3	13.6	16.0	13.0	1.9	8.1	18.7	9.6	3.6
HT	9.7	15.0	17.1	13.9	1.3	8.0	17.1	8.8	3.9
LP	9.0	12.2	12.2	11.1	3.1	8.1	15.5	8.9	4.1
HP	12.5	11.4	15.6	13.2	2.6	10.3	19.3	10.7	4.5
M14	18.5	27.2	21.5	22.4	1.2	8.2	15.8	8.4	2.7
C103	9.8	5.3	7.5	7.5	1.3	7.2	17.4	8.6	3.1
M14 x C103	5.5	13.1	16.3	11.6	1.5	9.1	20.2	10.3	4.2
Mean	10.6	13.2	15.6	13.1	2.2	8.5	18.7	9.8	4.0

Table 50. Analysis of variance when stability parameters are estimated for the composite experiment at five locations, Ames, Ankeny, Hampton, Newell and Sheldon, at five rates, 12,000, 16,000, 20,000, 24,000 and 28,000 plants per acre, 1964

Source	d.f.	SS	MS		F[a]	b
Total	174	14,730.58				
Entries	6	1,441.70	240.28	(MS_1)	24.26**	
Environments Entries x environments	168	13,233.84				
Environments linear	1	11,640.90				
Entries x environments linear	6	53.63	8.94	(MS_2)	0.90	
Pooled deviations	161	1,594.34	9.90	(MS_3)		
LT	23	108.66	4.72			1.05
HT	23	185.84	8.08			0.94
LP	23	215.58	9.37			1.00
HP	23	118.06	5.13			1.01
M14	23	300.75	13.08			0.78
C103	23	499.25	21.71			1.08
M14 x C103	23	166.20	7.23			1.12

[a]F-tests of significance: MS_2/MS_3 differences among regression coefficients MS_1/MS_3 difference among variety means

Table 51. Analysis of variance when stability parameters are estimated for individual line crosses at three locations, Ames, Ankeny and Hampton at 12,000, 18,000 and 24,000 plants per acre, 1964

Source	d.f.	SS	MS	F[a]	b
Total	71	3,481.25			
Entries	7	887.38	126.77 (MS_1)	12.47**	
Environments Entries x environments	64	2,593.87			
Environments linear					
Entries x environments	1	1,879.48	20.47 (MS_2)	2.01	
linear	7	143.29			
Pooled deviations	56	569.10	10.16 (MS_3)		
E	7	112.21	16.03		0.85
LT	7	19.63	2.80		1.06
HT	7	6.16	0.88		1.06
LP	7	2.64	0.38		1.08
HP	7	7.88	1.13		0.90
M14	7	204.23	29.18		0.66
C103	7	100.14	14.31		0.41
M14 x C103	7	116.20	16.60		1.24

[a]F-tests of significant: MS_2/MS_3 differences among regression coefficients MS_1/MS_3 differences among variety means

Table 52. Analysis of variance of 1964 inbred grain moisture at harvest for selections from M14 x C103, and M14 and C103

Source	d.f.	SS	MS	F
Reps	4	41.81	10.45	10.70*
Rates (R)	1	33.65	33.65	34.44**
Reps x rates	4	3.91	0.98	
Entries	62	1576.84	25.43	14.37**
LT vs HT	1	1.62	1.62	0.91
LP vs HP	1	0.23	0.23	0.13
T vs P	1	65.62	65.62	37.08**
E vs (P + T)	1	0.36	0.36	0.20
Selections vs checks	1	33.22	33.22	18.77**
Among E	2	117.59	58.80	33.21**
Among LT	12	326.02	27.17	15.35
Among HT	12	557.21	46.43	25.80**
Among LP	15	139.73	9.32	5.17**
Among HP	15	327.04	21.80	12.11**
Among checks	1	8.19	8.19	4.55*
Entries x rates	62	210.61	3.40	1.92**
LT vs HT x R	1	2.70	2.70	1.50
LP vs HP x R	1	1.24	1.24	0.69
T vs P x R	1	0.68	0.68	0.38
E vs (P + T) x R	1	0.01	0.01	0.00
Selections vs checks x R	1	0.00	0.00	0.00
Among E x R	2	8.43	4.22	2.38**
Among LT x R	12	34.78	2.90	1.61
Among HT x R	12	46.90	3.91	2.20**
Among LP x R	15	62.78	4.18	2.36**
Among HP x R	15	45.64	3.04	1.71*
Among checks x R	1	7.44	7.44	4.19*
Error b	496	879.74		
Total	629			

Table 53. Average agronomic data obtained for 36 F_7 selections from M14 x C103 and for M14 and C103 in a replicated experiment at 2 stand levels, 12,000 and 24,000 plants per acre, grown at Ames in 1963

	Yield cwt per acre		Grain Moisture %		Date in July Pollen shed		Date in July Silked		Differ. Silk Pollen shed		% Barren Stalks	
Selection No.	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
LP												
1501-1-2-2	30.7	45.3	16.1	15.5	24.0	24.4	24.6	24.8	0.6	0.4	2.5	1.3
1506-1-2-1	25.2	32.2	14.0	13.1	22.8	23.4	24.2	25.8	1.4	2.4	3.9	18.5
1515-1-1-1	29.2	37.6	12.6	12.9	22.6	22.8	23.0	23.6	0.4	0.8	2.6	2.7
1518-2-2-2	30.1	42.7	12.8	12.8	25.4	24.2	26.0	25.2	0.6	1.0	0.0	3.2
1524-1-1-1	30.2	42.2	12.7	12.7	27.4	25.6	27.6	25.8	0.2	0.2	4.1	6.1
1528-1-2-1	29.5	39.4	13.4	12.4	23.4	23.8	24.4	25.0	1.0	1.2	1.2	3.6
1534-1-2-1	31.4	39.1	14.0	14.3	23.8	24.2	23.6	24.6	-0.2	0.4	1.3	5.8
1550-2-2-2	34.2	43.3	15.6	14.9	24.6	23.8	26.8	28.4	2.2	4.6	1.3	3.8
1572-1-2-2	31.7	49.3	14.4	14.3	25.2	25.4	27.0	26.0	1.8	0.6	2.5	0.0
1574-2-1-1	32.3	34.7	11.8	12.6	22.8	23.0	24.2	25.8	1.4	2.8	2.7	4.2
1576-1-1-1	30.9	38.2	16.1	16.3	26.0	26.2	26.6	29.2	0.6	3.0	1.3	8.4
1592-1-2-2	33.6	47.3	15.6	15.9	27.0	27.0	28.0	28.4	1.0	1.4	0.0	3.8
1593-1-1-1	31.3	42.5	14.4	16.0	31.4	31.2	31.6	32.0	0.2	0.8	0.0	2.0
1595-1-1-1	29.2	35.9	14.2	14.4	25.8	26.2	26.8	27.4	1.0	1.2	5.3	11.0
1604-2-2-1	35.5	43.6	17.0	16.6	28.0	28.2	28.8	29.8	0.8	1.6	2.6	2.6
1606-1-1-1	39.3	53.7	15.4	15.1	24.2	24.4	26.0	26.8	1.8	2.4	0.0	0.6
1635-1-1-2	28.3	49.0	16.4	15.8	23.2	23.4	25.6	25.0	2.4	1.6	11.4	2.6
1638-1-2-1	36.4	53.1	15.0	15.5	25.8	25.4	26.0	25.8	0.2	0.4	0.0	1.3
Group Mean	31.6	42.7	14.5	14.5	25.2	25.1	26.2	26.6	1.0	1.5	2.4	4.5
Mean	37.2		14.5		25.2		26.4		1.2		3.8	

Table 53 (Continued)

Selection No.	Yield cwt per acre Low	Yield cwt per acre High	Grain Moisture % Low	Grain Moisture % High	Date in July Pollen shed Low	Date in July Pollen shed High	Date in July Silked Low	Date in July Silked High	Differ. Silk Pollen shed Low	Differ. Silk Pollen shed High	% Barren stalks Low	% Barren stalks High
HP												
1501-1-2-1	30.0	39.1	13.3	14.5	24.0	24.8	24.4	26.0	0.4	1.2	2.6	3.2
1504-1-1-1	32.8	44.7	13.5	13.8	24.4	24.0	25.0	25.2	0.6	1.2	0.0	0.8
1511-1-2-1	25.2	35.0	13.3	13.7	24.2	23.4	25.0	24.4	1.0	0.8	1.3	1.3
1515-1-2-1	34.1	48.7	12.3	12.9	23.8	23.6	24.2	24.0	0.4	0.4	3.8	1.3
1522-1-1-1	24.8	34.5	12.8	13.7	26.6	27.0	29.0	30.2	2.4	3.2	5.4	13.9
1523-1-2-1	18.0	30.8	16.2	16.8	27.2	26.2	29.2	30.0	2.0	3.8	12.0	7.1
1534-2-1-1	47.0	57.4	16.7	17.8	29.0	28.6	30.2	30.6	1.2	2.0	0.0	2.0
1548-1-1-1	35.9	47.2	14.3	15.0	28.4	30.4	29.4	32.0	1.0	1.6	1.3	2.6
1553-1-1-2	39.2	52.2	12.7	12.3	22.4	23.0	23.4	23.6	1.0	0.6	0.0	3.4
1556-1-2-1	32.0	46.4	15.6	14.4	23.4	23.8	25.8	26.4	2.4	2.6	2.5	2.5
1570-1-1-1	30.6	46.5	13.0	13.2	23.2	23.6	23.4	24.0	0.2	0.4	1.4	0.8
1574-1-2-1	34.3	35.8	12.2	13.0	23.0	23.0	23.8	25.4	0.8	2.4	0	4.8
1582-2-1-1	30.2	41.4	14.4	15.0	22.4	23.0	23.4	24.4	1.0	1.4	2.6	2.6
1583-2-1-2	41.3	60.8	15.0	14.3	25.0	25.2	25.8	26.0	0.8	0.8	1.3	0.0
1602-2-1-1	37.9	62.1	15.0	15.3	28.0	27.6	27.6	27.8	-0.4	0.2	6.3	7.8
1620-1-1-1	35.6	49.3	15.3	14.8	26.0	25.2	26.4	25.6	0.4	0.4	1.3	1.9
1632-1-1-1	34.9	42.8	14.2	13.3	24.4	24.6	25.0	26.2	0.6	1.6	0.0	1.9
1638-2-2-1	32.4	58.2	13.4	13.3	22.6	22.8	24.2	24.8	1.6	2.0	6.2	1.3
Group Mean	33.1	46.3	14.0	14.3	24.9	25.0	25.8	26.5	1.0	1.5	2.6	3.3
Mean	39.7		14.2		24.9		26.2		1.2		3.1	
M14	36.8	45.7	13.6	12.9	25.2	25.2	25.6	25.4	0.4	0.2	1.3	1.4
C103	17.2	20.3	15.5	16.8	27.6	27.4	30.2	34.2	2.6	6.8	14.5	26.2

Table 54. Agronomic data for 36 F_7 selections from M14 x C103 and for M14 and C103 obtained in a replicated experiment and combined over 2 stand levels

Selection No.	Yield cwt per acre	Grain moisture %	Date in July pollen shed	Date in July silks emerged	Difference Silked-Pollen shed	Barren stalks %
LP						
1501-1-2-2	38.0	15.8	24.2	24.7	0.5	1.7
1506-1-2-1	28.7	13.5	23.1	25.0	1.9	13.7
1515-1-1-1	33.4	12.8	22.7	23.3	0.6	2.7
1518-2-2-2	36.4	12.8	24.8	25.6	0.8	2.1
1524-1-1-1	36.2	12.7	26.5	26.7	0.2	5.4
1528-1-2-1	34.5	12.9	23.6	24.7	1.1	2.8
1534-1-2-1	35.3	14.2	24.0	24.1	0.1	4.3
1550-2-2-2	38.7	15.2	24.2	27.6	3.4	3.0
1572-1-2-2	40.5	14.3	25.3	26.5	1.2	0.9
1574-2-1-1	33.5	12.2	22.9	25.0	2.1	3.7
1576-1-1-1	34.5	16.2	26.1	27.9	1.8	6.0
1592-1-2-2	40.5	15.7	27.0	28.2	1.2	2.6
1593-1-1-1	36.9	15.2	31.3	31.8	0.5	1.3
1595-1-1-1	32.5	14.3	26.0	27.1	1.0	9.0
1604-2-2-1	39.5	16.8	28.1	29.3	1.2	2.6
1606-1-1-1	46.5	15.2	24.3	26.4	2.1	0.4
1635-1-1-2	38.7	16.1	23.3	25.3	2.0	5.6
1638-1-2-1	44.8	15.3	25.6	25.9	0.3	0.9
Means LP	37.2	14.5	25.2	26.4	1.2	3.8
HP						
1501-1-2-1	34.5	13.9	24.4	25.2	0.8	3.0
1504-1-1-1	38.7	13.7	24.2	25.1	0.9	0.5
1511-1-2-1	30.1	13.5	23.8	24.7	0.9	1.3
1515-1-2-1	41.4	12.6	23.7	24.1	0.4	2.1
1522-1-1-1	29.6	13.3	26.8	29.6	2.8	11.1
1523-1-2-1	24.4	16.5	26.7	29.6	2.9	8.7
1534-2-1-1	52.2	17.3	28.8	30.4	1.6	1.3
1548-1-1-1	41.6	14.7	29.4	30.7	1.3	2.1
1553-1-1-2	45.7	12.5	22.7	23.5	0.8	2.2
1556-1-2-1	39.2	15.0	23.5	26.1	2.5	2.5
1570-1-1-1	38.5	13.1	23.4	23.7	0.3	1.1
1574-1-2-1	35.1	12.6	23.0	24.6	1.6	3.1
1582-2-1-1	35.8	14.7	22.7	23.9	1.2	2.6
1583-2-1-2	51.1	14.1	25.1	25.9	0.8	0.4
1602-2-1-1	50.0	15.2	27.8	27.7	-0.1	7.3
1620-1-1-1	42.5	15.1	25.6	26.0	0.4	1.7
1632-1-1-1	38.9	13.8	24.5	25.6	1.1	1.3

Table 54 (Continued)

Selection No.	Yield cwt per acre	Grain moisture %	Date in July: pollen shed	Date in July: silks emerged	Difference Silked-Pollen shed	Barren stalks %
1638-2-2-1	45.3	13.4	22.7	24.5	1.8	3.0
Means HP	39.7	14.2	24.9	26.2	1.2	3.1
M14	41.2	13.2	25.2	25.5	0.3	1.3
C103	18.8	16.2	27.5	32.2	4.7	21.5

Table 55. Average agronomic data obtained from 61 inbred selections from M14 x C103, 29 lines developed on the basis of testcross performance and 32 lines developed on the basis of phenotypic appearance, and M14 and C103 in a replicated experiment at 2 stand levels, 12,000 and 24,000 plants per acre, grown at the Agronomy Farm, Ames, Iowa, 1964

Entry	Yield		% H_2O		Root lodging		Stalk lodging		Date silk		Date tassel		% Barren		Ears per plant	
	12	24	12	24	12	24	12	24	12	24	12	24	12	24	12	24
1	20.5	32.1	16.5	15.5	1.0	16.2	0.0	0.2	30.6	32.0	28.6	30.0	0.0	10.0	1.2	0.9
2	28.1	33.6	14.6	15.4	4.2	7.6	0.0	1.0	27.8	30.0	27.2	29.2	0.0	0.0	1.3	1.0
3	32.6	44.0	18.8	20.4	3.0	2.4	0.0	0.0	29.4	31.0	29.2	30.8	0.0	0.0	1.0	0.9
$\bar{x}$ Elite	27.1	36.6	16.6	17.1	2.7	8.7	0.0	0.4	29.3	31.0	28.3	30.0	0.0	3.3	1.2	0.9
4	26.1	37.9	19.1	21.3	2.6	4.2	0.0	0.2	31.6	33.2	29.4	31.0	20.0	0.0	0.8	1.0
5	21.4	26.6	15.7	16.4	0.2	0.4	0.0	0.0	33.4	34.4	31.0	33.2	10.0	20.0	0.9	0.8
6	14.8	19.1	16.2	17.2	0.8	1.6	0.0	0.0	30.2	32.4	26.4	26.6	0.0	10.0	1.1	0.9
7	23.6	34.1	13.6	15.3	3.4	2.2	0.0	0.2	29.6	31.8	27.6	29.0	0.0	0.0	1.4	1.0
8	18.7	19.5	16.6	15.3	2.0	4.6	0.0	0.0	32.4	35.8	31.4	32.6	10.0	30.0	0.9	0.7
9	19.9	25.9	15.3	16.8	1.2	0.8	0.0	0.2	29.6	33.0	28.6	31.4	0.0	10.0	1.0	0.9
10	28.7	39.0	18.3	19.9	2.2	3.2	0.4	0.8	30.2	32.8	29.0	32.0	0.0	10.0	1.3	0.9
11	23.1	32.6	16.0	17.8	3.8	8.8	0.0	0.0	31.8	33.8	29.4	31.8	0.0	10.0	1.0	0.9
12	17.8	17.6	17.0	17.0	0.0	0.4	0.0	0.2	32.8	34.8	29.0	28.4	1.0	20.0	1.1	0.8
13	19.7	26.4	19.8	19.2	1.4	6.6	0.2	0.0	29.4	32.6	27.0	32.8	0.0	10.0	1.0	0.9
14	29.9	31.9	16.1	16.3	1.6	0.4	0.0	0.0	29.0	30.8	27.6	30.8	0.0	20.0	1.0	0.8
15	26.7	43.4	16.2	15.8	4.6	6.0	0.0	0.0	31.4	32.8	32.6	30.5	10.0	0.0	0.9	1.0
16	22.6	26.8	16.9	18.1	0.2	0.0	0.0	0.0	32.0	35.2	29.2	32.2	0.0	10.0	1.2	0.9
$\bar{x}$ LT	22.5	29.3	16.7	17.4	1.8	3.0	0.0	0.1	31.0	33.3	29.1	30.5	3.9	10.8	1.0	0.9
17	17.1	17.6	16.0	18.0	1.6	2.8	0.0	0.0	33.8	36.4	31.2	32.2	0.0	20.0	0.9	0.8

Table 55 (Continued)

Entry	Yield 12	Yield 24	% H_2O 12	% H_2O 24	Root lodging 12	Root lodging 24	Stalk lodging 12	Stalk lodging 24	Date silk 12	Date silk 24	Date tassel 12	Date tassel 24	% Barren 12	% Barren 24	Ears per plant 12	Ears per plant 24
18	28.2	42.7	15.6	15.2	8.8	14.4	0.0	1.0	28.4	29.6	28.6	30.0	0.0	0.0	1.3	1.0
19	27.0	31.4	16.1	18.2	0.4	0.0	0.0	0.0	33.8	35.0	31.6	31.6	0.0	10.0	1.2	0.9
20	23.0	31.7	18.9	18.8	7.8	8.4	0.0	0.0	29.4	30.8	27.8	29.2	20.0	0.0	0.8	1.0
21	14.1	19.3	14.3	16.1	0.8	0.0	0.0	0.0	30.8	33.4	29.2	30.6	20.0	20.0	0.8	0.8
22	25.6	39.6	15.5	14.9	5.2	4.4	0.0	0.0	28.4	29.4	27.6	28.0	0.0	10.0	1.0	0.9
23	24.7	32.9	16.3	15.1	11.6	22.0	0.0	0.2	30.6	32.8	30.0	31.6	0.0	10.0	1.1	0.9
24	29.8	37.7	20.2	22.2	2.6	14.2	0.0	0.0	35.2	35.2	33.4	33.6	0.0	0.0	1.6	1.1
25	29.1	43.1	16.7	15.2	1.4	0.8	0.2	0.2	29.0	31.6	29.0	29.8	10.0	10.0	0.9	0.9
26	17.3	17.2	18.8	18.9	1.2	1.0	0.0	0.4	34.8	35.8	33.6	34.0	10.0	30.0	0.9	0.7
27	22.3	33.7	15.6	15.4	2.4	11.4	0.0	0.0	29.6	30.0	27.6	28.6	10.0	20.0	0.9	0.8
28	4.7	9.4	16.0	16.8	5.6	10.8	0.0	0.0	35.0	36.2	29.8	31.2	50.0	40.0	0.5	0.6
29	20.5	24.1	21.3	21.1	0.2	0.0	0.0	0.0	34.0	34.4	33.4	33.2	0.0	30.0	1.0	0.7
$\bar{x}$ HT	21.8	29.3	17.0	17.4	3.8	6.9	0.0	1.0	31.7	33.1	30.2	31.0	9.2	16.9	1.0	0.8
30	20.2	30.6	17.6	18.1	1.0	0.2	0.0	0.2	30.8	32.4	29.4	30.6	0.0	0.0	1.0	1.0
31	22.2	33.5	14.5	15.2	0.2	1.0	0.0	0.0	30.2	30.6	30.2	30.4	20.0	10.0	0.8	0.9
32	29.3	28.8	15.3	15.0	0.0	0.2	0.0	0.4	28.6	30.6	28.6	30.6	0.0	10.0	1.0	0.9
33	24.8	35.9	17.1	18.1	0.4	0.2	0.2	0.0	28.6	31.0	27.4	28.4	10.0	0.0	0.9	1.0
34	22.5	21.8	16.8	15.9	0.4	0.4	0.0	0.2	29.0	30.2	28.4	28.4	0.0	10.0	1.0	0.9
35	29.2	41.5	16.4	14.4	0.6	0.4	0.0	0.0	32.6	34.2	29.0	30.6	10.0	10.0	0.9	0.9
36	25.0	40.5	15.9	16.8	1.4	0.8	0.2	0.0	30.6	31.8	29.8	31.0	0.0	0.0	1.0	1.0
37	22.2	34.1	14.8	15.5	0.0	0.0	0.0	0.0	29.6	32.8	26.6	27.8	0.0	10.0	1.0	0.9
38	27.1	23.6	17.1	15.6	3.4	5.8	0.2	0.2	31.4	35.4	30.2	32.6	0.0	20.0	1.0	0.8
39	28.7	36.3	17.2	16.6	0.2	0.0	0.0	0.0	33.2	35.2	33.0	33.6	0.0	0.0	1.3	1.0
40	25.2	23.4	16.2	19.5	11.6	28.0	0.0	0.0	35.2	37.0	34.0	36.2	0.0	10.0	1.0	0.9
41	27.8	30.1	16.1	15.6	2.6	9.6	0.0	0.2	31.8	33.8	31.2	31.2	0.0	0.0	1.0	1.0
42	34.0	37.0	16.4	18.0	0.8	0.8	0.2	0.2	34.0	35.6	33.6	28.0	0.0	10.0	1.1	0.9

Table 55 (Continued)

Entry	Yield 12	Yield 24	% H_2O 12	% H_2O 24	Root lodging 12	Root lodging 24	Stalk lodging 12	Stalk lodging 24	Date silk 12	Date silk 24	Date tassel 12	Date tassel 24	% Barren 12	% Barren 24	Ears per plant 12	Ears per plant 24
43	27.9	39.5	17.2	16.9	1.4	5.2	0.0	0.0	30.8	33.4	28.2	29.2	0.0	0.0	1.0	1.0
44	29.7	41.5	16.3	17.6	2.4	3.2	0.0	0.0	29.2	31.0	28.4	29.6	0.0	0.0	1.0	1.0
45	29.3	45.1	16.5	17.1	2.6	4.8	0.0	0.0	29.4	30.6	28.0	28.8	0.0	0.0	1.0	1.0
$\bar{x}$ LP	26.6	33.9	16.3	16.6	1.8	4.7	0.1	0.1	30.9	32.8	29.7	30.4	2.5	5.6	1.0	0.9
46	24.3	32.6	14.3	15.3	4.8	7.6	0.4	2.4	30.0	31.4	27.8	29.0	20.0	10.0	0.8	0.9
47	17.2	28.1	15.1	14.7	5.0	7.4	0.0	0.0	30.6	32.4	30.4	30.6	0.0	10.0	1.0	0.9
48	31.0	47.5	15.2	16.1	1.4	1.2	0.0	0.0	28.2	29.8	28.2	29.8	0.0	0.0	1.1	1.0
49	19.8	21.2	15.8	15.8	0.0	0.4	0.0	0.2	34.0	36.8	32.0	34.4	20.0	20.0	0.8	0.8
50	28.6	41.4	18.4	21.2	9.8	16.8	0.0	0.0	34.4	35.4	33.6	34.0	0.0	0.0	1.6	1.0
51	19.8	23.0	16.3	16.9	0.8	0.4	0.0	0.0	36.4	37.6	34.0	35.4	20.0	10.0	0.8	0.9
52	24.9	38.6	16.0	15.9	1.8	0.6	0.0	0.2	28.2	28.8	27.4	27.4	20.0	0.0	0.8	1.0
53	22.7	29.8	17.6	16.3	0.4	3.4	0.2	0.0	32.4	33.2	29.4	28.6	10.0	10.0	0.9	0.9
54	31.5	41.4	14.6	15.8	0.4	5.4	0.0	0.0	27.8	30.0	27.4	29.6	0.0	10.0	1.0	0.9
55	23.9	36.3	15.2	16.4	2.0	2.8	0.0	0.2	28.4	28.2	26.6	27.6	0.0	0.0	1.2	1.0
56	22.0	33.6	18.0	17.5	4.6	2.6	0.2	0.0	29.4	31.8	27.2	28.4	0.0	0.0	1.1	1.0
57	30.5	38.7	15.3	15.5	3.0	7.2	0.0	0.6	30.0	31.8	29.0	31.2	0.0	0.0	1.3	1.0
58	32.1	56.4	18.8	19.9	1.6	5.8	0.0	0.0	29.6	31.2	31.0	31.4	0.0	0.0	1.1	1.0
59	31.4	39.8	17.0	17.6	2.4	4.6	0.0	0.6	30.4	31.0	30.4	30.2	10.0	10.0	0.9	0.9
60	31.1	35.0	15.9	15.0	4.4	3.4	0.0	0.0	28.0	32.2	27.8	29.6	0.0	0.0	1.1	1.0
61	26.3	46.4	15.0	17.3	4.2	6.4	0.0	0.0	28.0	29.4	26.6	27.0	20.0	10.0	0.8	0.9
$\bar{x}$ HP	26.1	36.9	16.1	16.7	2.9	4.7	0.0	2.6	30.4	31.9	29.3	30.3	7.5	5.6	1.0	0.9
M14	25.2	35.0	14.0	15.7	8.0	7.0	0.2	0.2	29.4	31.0	29.4	30.4	0.0	10.0	1.1	0.9
C103	12.9	11.4	16.5	15.7	0.4	00.0	0.2	0.0	36.0	38.0	31.6	32.8	40.0	60.0	0.6	0.4
$\bar{x}$ check	19.0	23.2	15.2	15.7	4.2	3.5	0.2	0.1	32.7	34.5	30.5	31.6	20.0	35.0	0.8	0.7
Grand $\bar{x}$	24.4	32.5	16.4	16.9	2.6	5.0	0.0	0.6	30.9	32.7	29.6	30.5	5.9	8.7	1.0	0.9